University of Technology, Sydney

INTELLIGENT M-GOVERNMENT SERVICES: A MOBILE-BASED EMERGENCY RESPONSE SYSTEM

A thesis submitted for the degree of Doctor of Philosophy

By

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Certificate of Authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

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Abstract

Recent advances in Internet technologies and services have allowed governments to deal with their citizens in a new way, through mobile platforms. The use of mobile technologies assists people by providing access to information anytime and anywhere. The demand for better, more efficient and more effective government services will put serious pressure on the government with regard to m-Government. m-Government is the next inevitable direction of the evolution of e-Government.

In an emergency response system, mobile technology can be used to link citizens, businesses and non-profit organisations. For example, in an emergency situation such as the 9/11 terrorist attack, mobile technology can be used to enhance productivity, connectivity and response and facilitate rapid access to information anytime and anywhere. This was the impetus of this research into emergency response systems based on mobile technology.

A mobile-based emergency response system (MERS) is as one of the important new services of m-Government. It aims to support people (mobile users) in emergency situations through their mobile phones by giving them access to essential advice and information. It also provides information to the government to reduce risks. The main goal of this study is to make use of mobile technology to assist in information dissemination and decision making in response to disasters anytime and anywhere. Design research methodology is employed to address the primary research question: How can m-Government be used for dealing with emergency response systems?

This research presents an MERS framework that has five main components—register, monitoring, analysis, decision support and warning—aiming to provide a new function and service to m-Government. The proposed framework would also offer a new opportunity for interaction among government, citizens, responders and other non-government agencies in emergency situations.

According to this MERS framework, relevant information system techniques (algorithms and approaches) were developed to support the most important applications for the MERS. These applications are ontology-based information extraction (OBIE) and aggregation and an ontology-supported case-based reasoning (OS-CBR) approach for the MERS. OBIE has four main functions: to collect unstructured information from short message service (SMS) emergency text messages; to conduct information extraction (IE) and aggregation including lexical analysis, name entity recognition, merging structure, normalisation and duplication; to calculate the similarity of SMS text messages; and to generate query and results presentation. The OS-CBR approach consists of four main functions: data acquisition, knowledge base, case-based reasoning (CBR) component, and knowledge presentation.

More important, a MERS prototype system has been designed and developed in this study. Experiments conducted to evaluate the major algorithm, approach and prototype system show that MERS, as an implementation of the IE algorithm and OS-CBR approach, is an effective means of classification in terms of precision, recall, F-measure and overall accuracy.

Chapter 1: Introduction

Basic research is what I am doing when I don't know what I'm doing.

Werner Von Braun

This chapter begins with an overview of the research in this thesis on a mobile-based emergency response system (MERS). Next, it discusses the scope of the study and the research questions, objectives, significance and methodology. Finally, it presents the layout and content of chapters. The organisation of this chapter is shown in Table 1.1.

Table 1.1: Organisation of Chapter 1

1.1	Research Overview
1.2	Scope of the Study
1.3	Research Questions
1.4	Research Objectives
1.5	Research Significance and Innovation
1.6	Research Methodology 1.6.1 Design Research 1.6.2 Research Process
1.7	Thesis Structure
1.8	Chapter Review

1.1 Research Overview

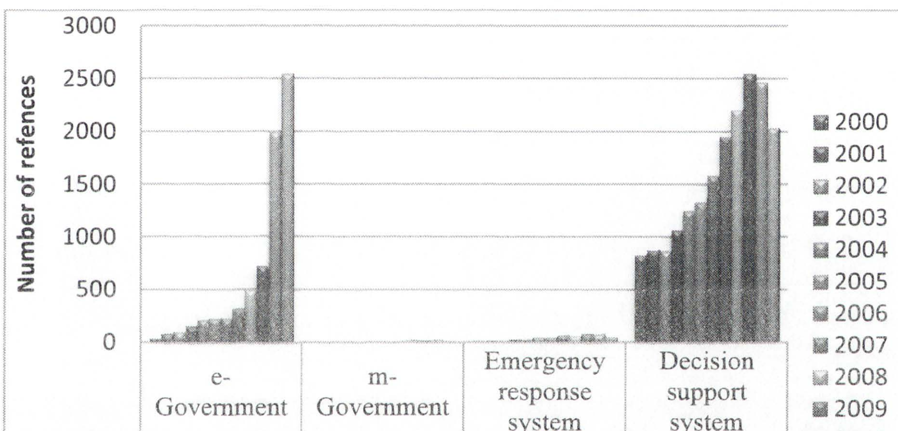
Within the context of electronic government (e-Government), mobile government (m-Government) services offer greater access to information and services for citizens, businesses and non-profit organisations through wireless communication networks and mobile devices such as Personal Digital Assistants (PDAs), mobile phones and their supporting systems (Ghatak et al. 2011; Kumar, Hanumanthappa & Reddy 2008; Moon 2004; Rodrigues, Ariza & Pascoe 2005). Mobile services (m-Services) are an m-Government dimension in the public sector, an example of which is crisis communication. In Great Britain, for example, people with a hearing disability can send a text message to an emergency number that can assist an emergency centre in locating the person in need and responding to them quickly (Huijnen 2006). In emergency situations such as the 9/11 terrorist attack, information communication technology (ICT) in the form of mobile telecommunications and the Internet have the potential to provide more capable and effective services in warning and response activities (Moon 2004).

As stated in (Careem et al. 2007), the objective of emergency response systems is to minimise the impact of a disaster on several organisations, including government agencies, businesses and volunteer organisations, as well as experts and residents. Disasters can be classified into two main categories: man-made and natural (NCRIS 2008). Emergency response systems, as one of the new m-Government services, facilitates access to electronic public services from anywhere and at any time in dealing with an emergency. The goal of this study is to make mobile devices valuable tools for emergency response systems under the platform of m-Government.

Studies show that mobile-based information systems can be a solution that benefits responders in a variety of ways. First, mobility devices allow first responders to perform better, rapid and actionable decision making. Second, the development of wireless/mobile technology and communication trends provides a ubiquitous environment for the deployment of mobile devices in a variety of fields (Kim et al. 2008). Third, using mobile devices will create interactive communication mechanisms that can facilitate just-in-time communication and collaboration among a large number of residents and responders (Paul et al. 2007). An MERS makes use of mobile technologies to assist governments in obtaining information and responding to disasters. It enables mobile users to report emergencies and to rapidly access information that may save their lives. This research mainly considers situations involving man-made disasters, such as bomb attacks, non-natural events, fire, chemical attacks and hijacking, all of which share common features in response system development.

1.2 Scope of the Study

The majority of current research in related areas has focused on the development and implementation of e-Government systems and specific emergency response systems such as e-Government in transition countries and dynamic project management. There has been little research published in the area of m-Government systems, in particular, in m-Government services for emergency management. Figure 1.1 presents a summary of the references for a given year containing one or more of the keywords 'e-Government', 'm-Government', 'emergency response system' and 'decision support system' from the on-line databases 'IEEE xplore' and 'Science Direct'.



	e-Government	m-Government	Emergency response system	Decision support system
2000	32	5	15	825
2001	85	7	11	870
2002	98	5	13	865
2003	155	1	21	1068
2004	210	2	28	1249
2005	232	7	42	1327
2006	227	6	45	1580
2007	319	4	68	1947
2008	498	17	58	2202
2009	719	18	81	2545
2010	1993	23	74	2468
2011	2551	12	50	2034

Figure 1.1: Summary of four main key words in the literature

The research areas addressed in this study are illustrated in Figure 1.2. The three key areas are m-Government, disaster management and emergency response systems. The study examines m-Government within the context of e-Government and its relationship to man-made disasters management and emergency response systems.

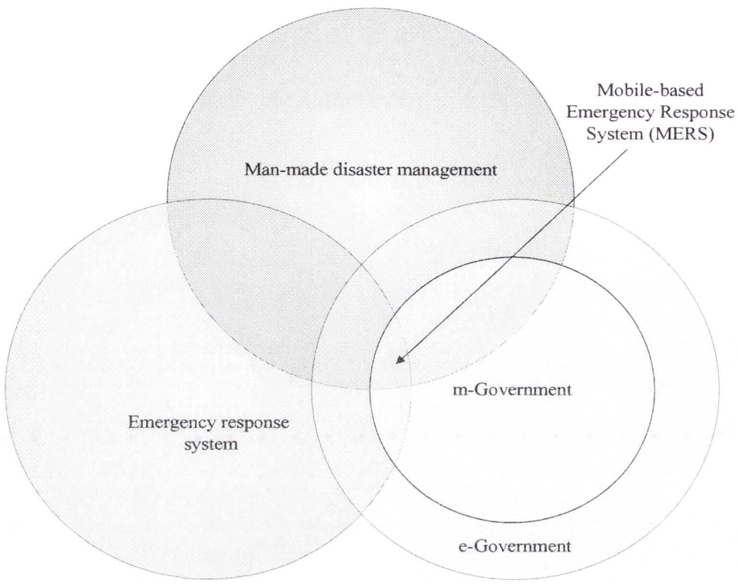


Figure 1.2: Key research areas of this study and their relations

1.3 Research Questions

Recent advances in Internet technologies and services have allowed governments to deal with citizens and businesses in new ways, through mobile platforms. The demand for better, more efficient and more effective government services will put serious pressure on governments with regard to m-Government (i.e. transparency, access, affordability and participation).

Emergency response systems, as an advanced m-Government services facilitates just-in-time communication and collaboration among a large number of residents and responders in a disaster situation. There is currently little research in the area of m-Government and emergency response systems. Thus, based on an extensive literature review, this study aims to expand in this domain by focusing on the primary research question: How can m-Government be used to support emergency responses system in dealing with emergencies in public places?

This raised three more detailed research questions that initiated the core work of this study:

1. What is the structure of a mobile-based emergency response system under m-Government? This question is concerned with making use of mobile technologies to assist government to obtain information and respond to disasters. In this way, every mobile user has the ability to report emergency information and to rapidly obtain information that may save his or her life.
2. What is an appropriate extraction and aggregation method/algorithm of an MERS to integrate data from different resources? From question 1, this question addresses information extraction (IE) and aggregation at a practical level (i.e. the specific IE technique that is required for an MERS).
3. How can an MERS support decision makers and governments risk managers in an emergency situation? In a disaster situation, decision makers' actions are intellectual and consist of a series of mental activates. However, an approach that facilitates learning from past situations is required. This research question is concerned with developing an approach that is able to improve the efficiency of decision makers in an emergency situation.

Examples of more detailed questions derived from the above research question are as follows:

1. How can an MERS support knowledge sharing between different organisations involved in a disaster situation?
2. What technique is needed for name entity recognition?
3. How can emergency response ontology be represented?
4. How can emergency situation CBR architecture be represented?

1.4 Research Objectives

Due to the rapid move towards the use of the Internet among government agencies and citizens, it is now possible to offer new services, integrated services, and self-services in ways and places were impossible in past the. These services are known as m-Government services. m-Government implementation provides unique opportunities to use mobile/wireless devices to receive government services and information from any place, at any time using varieties of wireless networks. However, these services present us with challenges such as privacy and security, accessibility and reliability. Governments seem to be very effective in providing better, more efficient and more effective government services; one of most important services is crisis communication (i.e.: people in a disaster area receive text message information). The research has the following objectives:

1. to develop an intelligent MERS framework as a function of m-Government services. This framework would be used before, during, and after a disaster to provide intelligent channels for sharing information, coordinating the responses of social networks and facilitating emergency decision making
2. to develop an extraction and aggregation algorithm to integrate information from a multiple sources in MERS system. The algorithm aims to extract relevant information from a SMS text, to produce a structured information output and to deposit the results into a database
3. to develop an intelligent approach for decision makers in MERS. The proposed system is a predicting CBR approach that facilitates learning from past situations to generate solutions to new problems based on past solutions for past problems
4. to develop a prototype system according to the MERS framework and information system (IS) technique devised here. This prototype system will be used to evaluate the new MERS framework with the approach and algorithms developed here.

1.5 Research Significance and Innovation

The research will propose a new model for emergency response systems. It is expected that the research will eventually lead to better government service performance in:

- serving citizens using mobile emergency information and a communication model
- integrating various government and non-government organisations that may involve in emergency response through mobile portals

- facilitating just-in-time communication and collaboration among large numbers of citizens and responders
- allowing information sharing and communication between citizens and responders during disasters
- providing reliable, up-to-date information for describing the current disasters situation
- providing assistance to specific groups of people such as disability people in a timely and meaningful way;
- providing an MERS framework that contributes to the research in m-government field;
- providing an extraction aggregation algorithm to combine information from different resources in MERS;
- providing an approach for a decision support system that has capability to improve the efficiency of decision makers in an emergency situation.

1.6 Research Methodology

The methodology used in this study is a set of procedures, techniques, tools and documentation aids that help the system developer to plan, manage, control and evaluate information system projects. A variety of different research methodologies have been applied in the IS domain such as case study, field study and design research. This study employed design research.

1.6.1 Design Research

The main function of design research is to create and analyse artefacts to find answers to research questions (problems). Examples of artefacts include human-computer interfaces, computer-based information systems, and human-computer interfaces (Li 2009). March and Smith (1995) stated four essential types of artefacts that are recognised as effective research outputs of the design science research process. These four types are constructs, models, methods, and instantiations. (Rossi & Sein 2003) suggest an additional fifth research output, known as better theories. Table 1.2 summarises the outputs that can be obtained from a design research effort.

Table 1.2: The outputs of design research

Output	Description
Constructs	The conceptual vocabulary of a domain
Models	A set of propositions or statements expressing relationships between constructs
Methods	A set of steps used to perform a task – how-to knowledge
Instantiations	The operationalisation of constructs, models and methods.
Better Theories	Artefact construction as analogous to experimental natural science

The methodology of design research is illustrated in Figure 1.3, which consists of five basic steps.

1.6.1.1 Awareness of Problem

This step is intended to define the specific research problem and justify the value of solution. The problem definition will be used to identify gaps or limitations of existing systems and to develop an effective artefact solution that captures the problem's complexity. The output of this step is a research proposal effort.

1.6.1.2 Suggestion

The suggestion step is based on the identification of research problems. The output is a tentative design that is a fundamental part of the research proposal. Suggestion is a creative step in which new functionality of artefacts is proposed. The step has necessary similarities in all research methods.

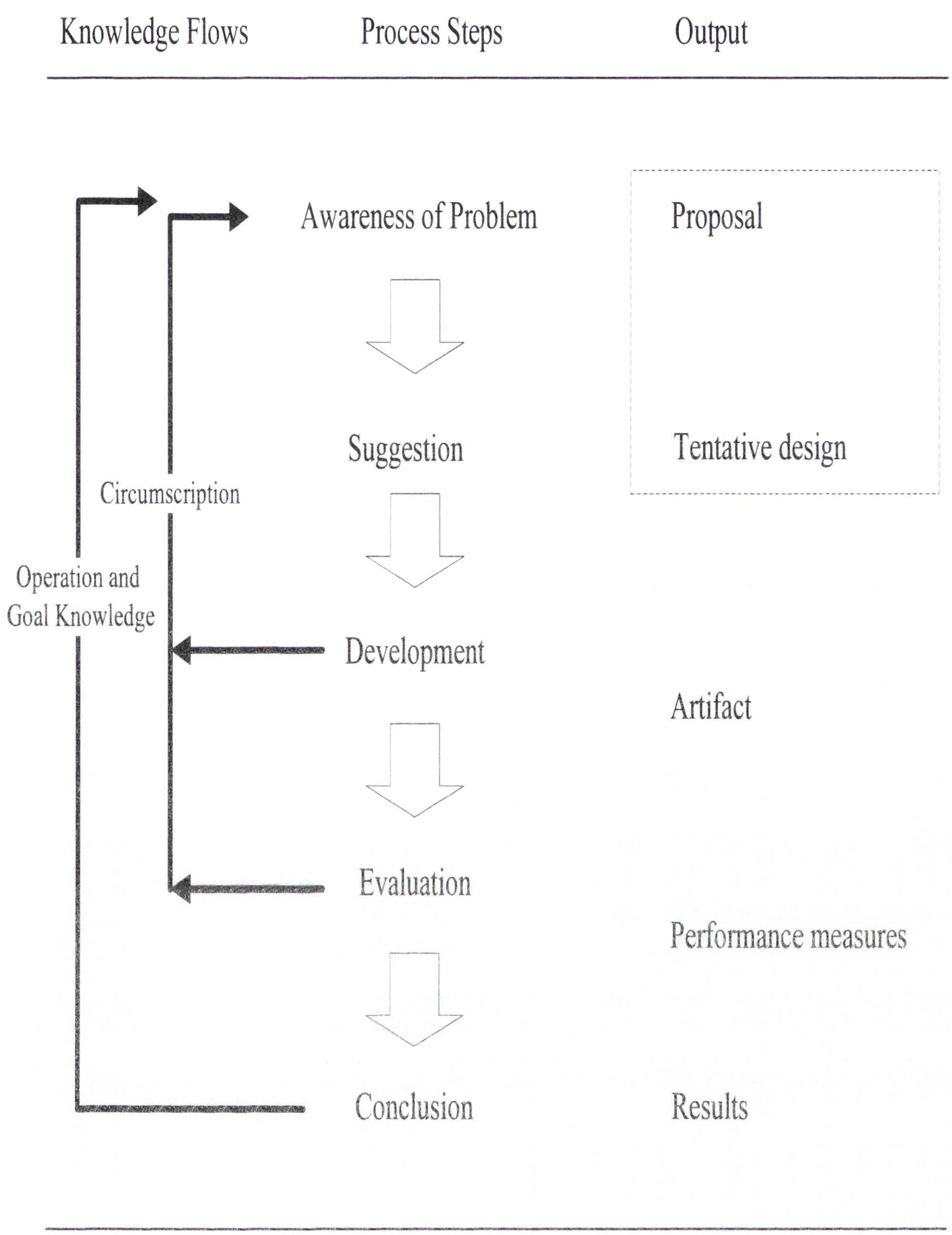


Figure 1.3: A general methodology of design research (Vaishnavi & Kuechler 2004)

1.6.1.3 Development

In this step, a solution has to be implemented in the form of an artefact based on the suggested design. The development of artefact can take several forms including constructs, models, methods, and instantiations. This step is an iterative process, and includes defining the artefact's desired functionality and its architecture and then creating the actual artefact.

1.6.1.4 Evaluation

Once the solution reaches a sufficient state, the researchers need to observe and measure the performance of the artefact according to criteria defined in the research proposal and the suggested design steps. This activity involves comparing the objectives of a solution to actual observed results from use of the artefact in the demonstration. As a result of this step, it is possible to iterate back to 'design artefact' or even 'identify problems' if necessary to improve the effectiveness of the artefact.

1.6.1.5 Conclusion

This step is the final of a design research effort.it is a summarisation phase, and reflects the result of satisficing. At the end of the process, the results can takes forms of report, papers of journal or conference, PhD thesis, etc.

1.6.2 Research Process

The research process that used in this study is shown in Figure 1.4. The research process consists of four stages.

1.6.2.1 Stage 1: Concept design (Theory)

This stage involves a substantial literature review to analyse the current technical and theoretical in the area of interest. The results of literature review helped to identify gaps or limitation of existing system and develop meaningful research objective.

Based on literature review, a conceptual framework of a MERS that represents general answers to the identified research questions was constructed. This stage is resulted in the publication of a paper on the MERS framework. Based on the conceptual of a MERS framework, detailed components of the MERS model are proposed.

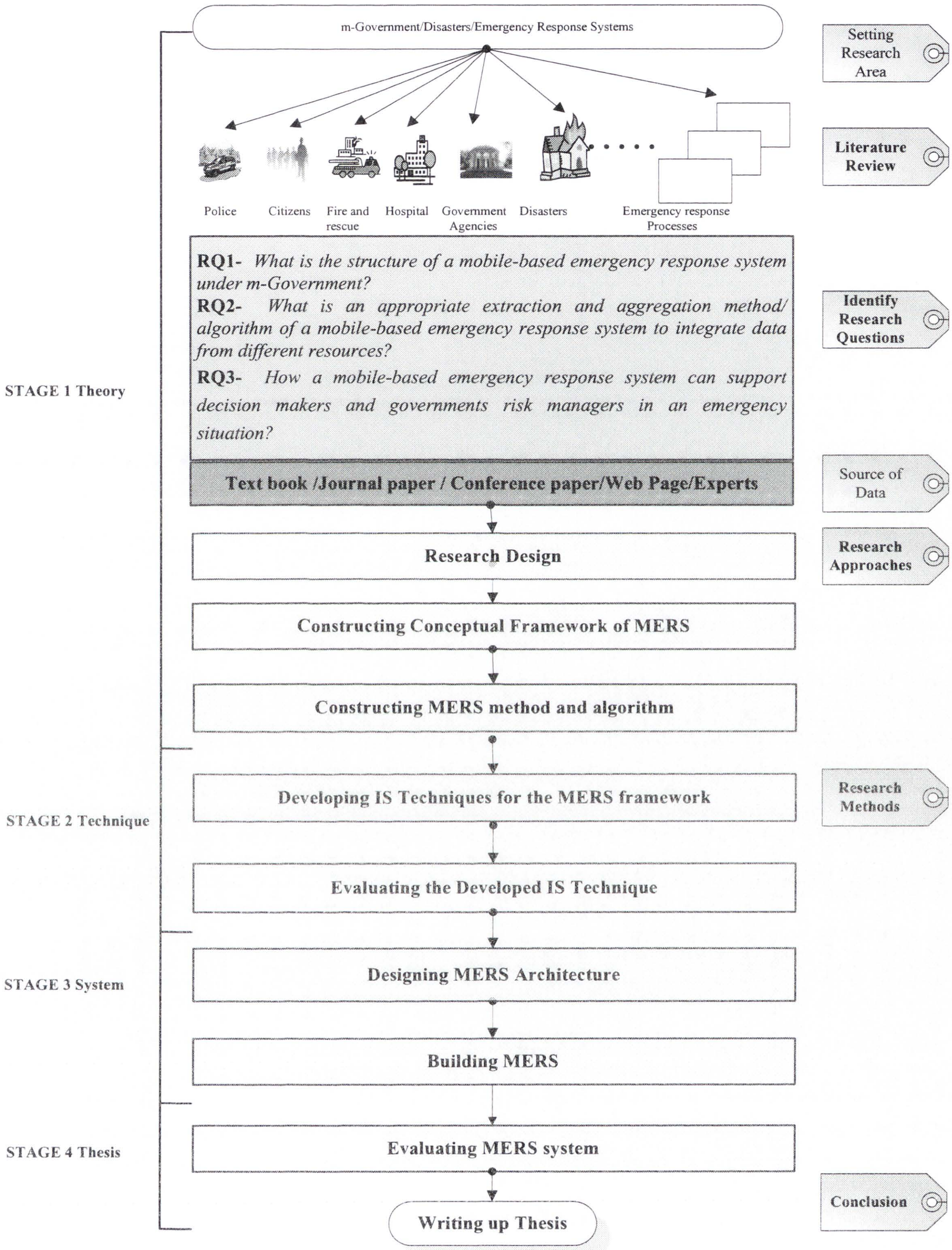


Figure 1.4: Research process

1.6.2.2 Stage 2: Technique

The major task of this stage is involving in the creative and innovative design activity of architecture development, defining components, method, algorithms and data structures. In practical application, this stage is used to implement the MERS model in design and development of the proposed emergency response system.

1.6.2.3 Stage 3: Prototyping

Prototyping of information systems is a worthwhile technique for quickly gathering specific information about users' information requirements. Prototyping usually occurs during the requirements determination phase of the systems development life cycle (SDLC). The systems analyst uses prototyping to seek initial reactions from users and management, as well as to elicit suggestions for the new system. It is possible that the suggestions will result in innovations that the analyst had not previously thought.

There are four conceptions of prototypes (Guo 2006):

1. **Patched-up prototype:** This kind of prototyping has to do with constructing a system that works but is patched up or patched together. An example in information system is a working model that has all the necessary features but is inefficient. In this instance of prototyping, users can interact with the system, becoming accustomed to the interface and types of output available.
2. **Non-operational prototype:** This prototype is a nonworking scale model that is set up to test certain aspect of the design. A nonworking scale model of an information system might be produced when the coding required by the applications is too extensive to prototype but when a useful idea of the system can be gained through the prototyping of the input and output only.
3. **First-of-a-series prototype:** This kind of prototype involves creating a first full-scale model of a system, often called a pilot. This type of prototyping is useful when many installations of the same information system are planned.
4. **Selected feature prototype:** This type of prototyping concerns building an operational model that includes some, but not all, of the features that the final system will have. When this kind of prototyping is done, the system is

accomplished in modules so that if the features that are prototyped are evaluated as successful, they can be incorporated into the larger, final system without undertaking immense work in interfacing.

This stage is used to show that a system can be built based on the results of the previous stage. This stage involves iterative analysis, design and implementation of a software prototype. A prototype system called MERS was designed. The architecture of MERS was designed based on techniques that were all developed previously. Its performance was evaluated in terms of emergency support. An emergency scenario was used for the evaluation of the MERS framework, approach and prototype.

1.6.2.4 Stage 5: Conclusion

At the end of the process, the results should be summarised in the form of a PhD thesis and a set of journal and conference publications.

1.7 Thesis Structure

This information systems research comprises eight chapters, which are outlined below (see Figure 1.5):

- **Chapter 1: Introduction.** The introduction to the thesis outlines the focus of study, research questions, and research objectives and highlights its overall significance.
- **Chapter 2: Literature Review.** This reviews the current literature as it relates to e-Government, especially m-Government, including emergency response system, ontology, current theory and standards of information extraction system and aggregation, and CBR approach. It concludes by focusing on the area of m-Services emergency management, and examining characteristics of this research domain.
- **Chapter 3: MERS.** This chapter presents the conceptual and technical frameworks of an MERS under an m-Government platform. The structure of the

system developed includes three main parts: m-Government dimensions, MERS project and end-users.

- **Chapter 4: Domain Knowledge Representation and Processing for MERS.** This chapter describes two types of domain knowledge—ontology and case base (CB)—to support the MERS.
- **Chapter 5: Ontology-Based IE and Aggregation for MERS.** This chapter describes an algorithm within a MERS to automatically extract information from short message services (SMSs).
- **Chapter 6: An OS-CBR System for an MERS.** In order to support and utilise decision support systems in an emergency situation, an approach of combination of CBR and ontology approach for the MERS is proposed in this chapter.
- **Chapter 7: The Prototype System—MERS.** This type of prototyping concerns building an operational model that includes some, but not all, of the features that the final system will have. When this kind of prototyping is done, the system is accomplished in modules so that if the features that are prototyped are evaluated as successful, they can be incorporated into the larger, final system without undertaking massive work in interfacing.
- **Chapter 8: System Evaluation.** This chapter presents the experiments conducted to evaluate the performance of a MERS proposed in this research. This chapter has been expanded into two sections, experimental design and analysis of experimental results.
- **Chapter 9: Conclusions and Future Work.** This chapter draws a conclusion, discusses the limitations of this study, and suggests some research directions for the future.

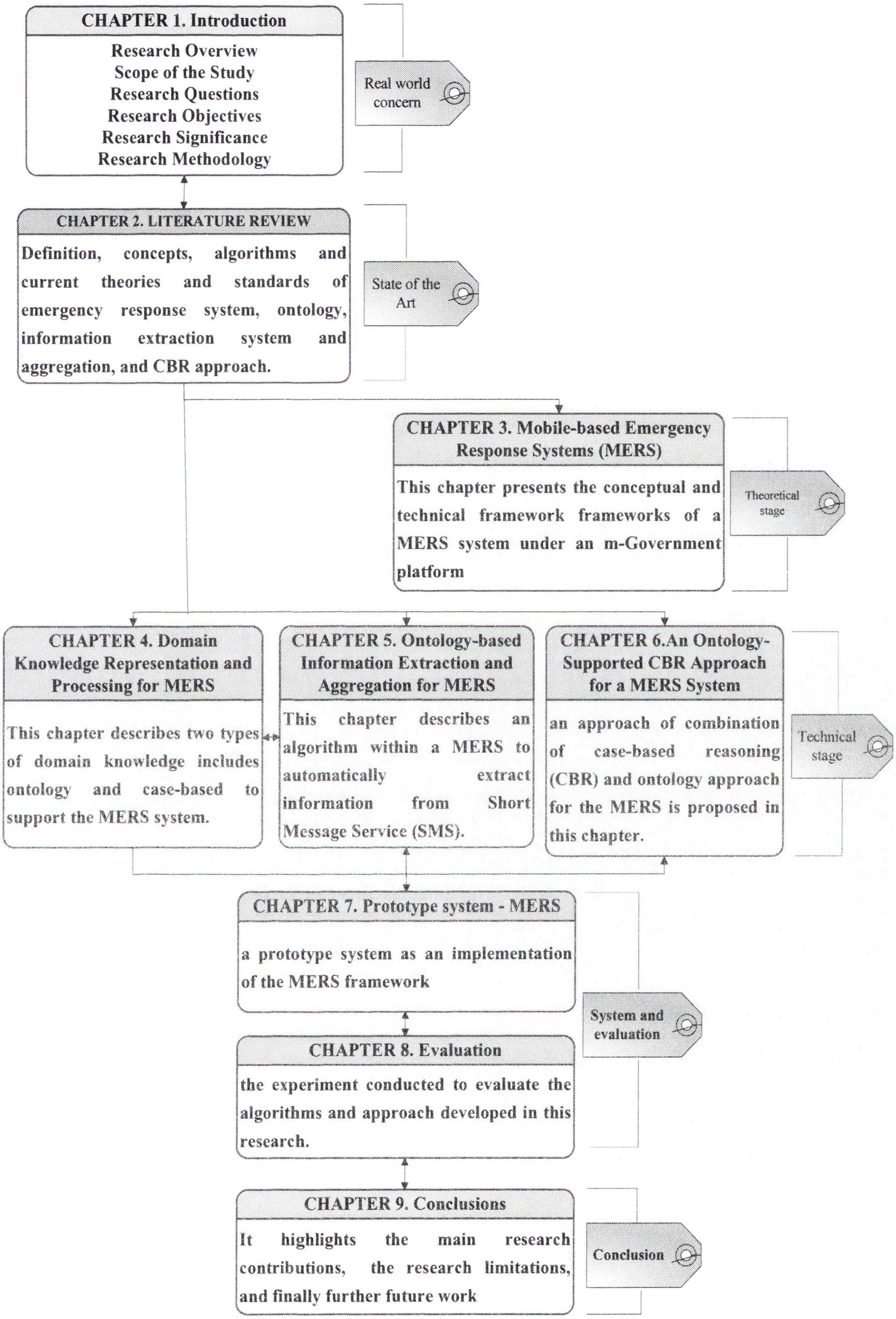


Figure 1.5: Thesis structure

1.8 Chapter Review

The purpose of this chapter was to introduce the key aspect of this research. The scope of the study was described as a step towards defining the area where the research problem existed. Subsequently, the research questions were raised, as the objective of the study was stated. The research methodology was briefly discussed in order to develop, plan, manage, control and evaluate the project. In addition, significance was also handled before the thesis outline concluded this chapter.

Chapter 2: Literature Review

Unless you try to do something beyond what you have already mastered, you will never grow.

Ralph Waldo Emerson

This chapter presents a review of the literature on the role and management of emergency response systems. It begins by defining key areas of the research: m-government, emergency response systems, information extraction, case-based reasoning and ontology. Key research issues and potential research areas are then identified for investigation in this thesis. . An organisation of this chapter is explained in Table 2.1.

Table 2.1: Organisation of Chapter 2

2.1	Background
2.2	Mobile-Based Telecommunications
2.3	From e-Government to m-Government 2.3.1 m-Government Services 2.3.2 Benefits and Challenges of m-Government
2.4	Emergency Response Systems 2.4.1 Traditional Emergency Response Systems 2.4.2 Web-Based Emergency Systems
2.5	IE and Aggregation 2.5.1 Definition of IE and Aggregation 2.5.2 Extraction Methods
2.6	CBR Approach
2.7	Ontology 2.7.1. Ontology Definition 2.7.2. Ontology Development Process
2.8	State of Research
2.9	Chapter Review

2.1 Background

In the early 1990s, Internet technology and its standardised protocols attracted many governments to offer their public services and promote policies and political participation through World Wide Web (El-Kiki & Lawrence 2006). The last decade has witnessed a revolution in ICT. This revolution is not only changing the daily lives of people but is also changing the characteristics of interactions between governments and citizens. These changes, in turn, are rapidly being transformed into new forms of government named e-Government (Zarei, Ghapanchi & Sattary 2008).

This chapter briefly sets out the important literature of mobile government (m-Government), an extension of the growing movement towards electronic government (e-Government). Specifically, the relevant literature is reviewed on m-Government particularly in the area of emergency response systems and their relationship to man-made disasters and public safety

2.2 Mobile-Based Telecommunications

Mobile and wireless technologies have developed with high-speed data transfer, and a high range of information and services that can now be accessed using mobile devices. Mobile phones and other devices such as PDAs have a number of facilities include as text, audio and video data transfer. The users of mobile phones can easily now communicate by voice, email or SMS, send images, and stream audio and video files (Urbas & Krone 2006).

According to the International Telecommunications Union (ITU) (ITU 2011) the total number of mobile users worldwide as of late 2010 is estimated to be 5.3 billion as seen in Figure 2.1, which represents more than 90 per cent of the world population and 80 per cent of the population living in rural areas, including 940 million who use third-generation (3G) mobile services subscribers. Mobile subscription reached 68 per cent in the developing world at the end of 2010. At the same time, in Africa region distribution rate of mobile subscription was estimated to be 41 per cent. However, in Ghana, statistics provided in (Dogbevi & Quandzie 2011) show that the number of mobile phone users has reached 75 per cent of the country's 23 million people.
Between 2007 and 2010, 6.1 trillion SMS text messages have been sent internationally. In other words, about 200,000 text messages are sent every second. This provides an

opportunity to assist citizens to use mobile technologies to access information anytime and anywhere.

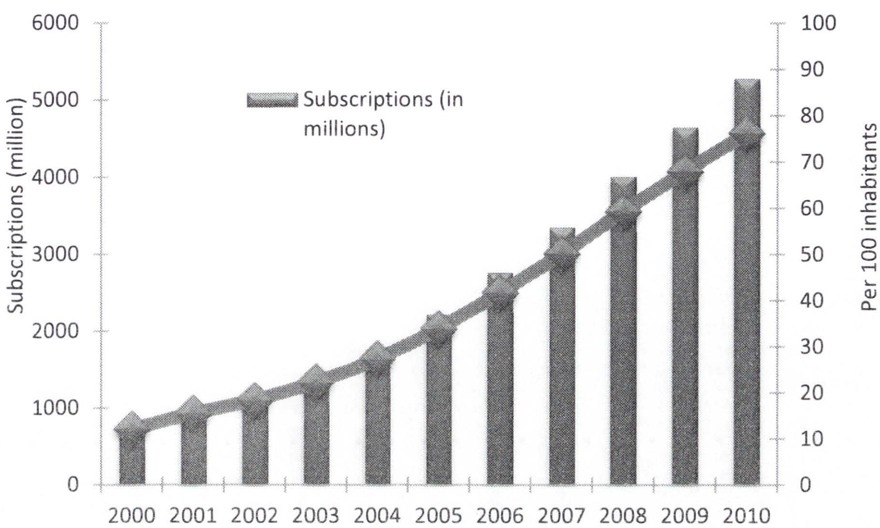


Figure 2.1: Global mobile cellular subscriptions

2.3 From e-Government to m-Government

e-Government has the greatest opportunity to improve the interaction between citizens and their government in terms of information accessibility, improving the effectiveness and efficiency, and brining citizens close to government officials. The term e-Government is defined as the use of ICT, in particular the Internet, to provide access to the government information and services (Niehaves & Plattfaut 2010; Shareef et al. 2011; Verdegem & Verleye 2009).

The development of e-Government is often modelled by a number of stages, Layne and Lee (2001) defines different stages of e-Government development and proposes a model for a fully functional e-Government. The model consists of four stages of e-Government growth includes cataloguing, transaction, vertical integration, and horizontal integration. the three ring model that captures all Internet applications in three stages: informational use, transactional use, and operational use (Koh & Prybutok 2003). The Moon model identifies five stages of e-Government reflected the degree of technical difficulty and interaction with users. The model of El-Kiki and Lawrence (2006) extends the Moon model by adding a sixth stage, which is an expected outcome from the development of wireless and mobile technologies.

Recent advances in Internet technologies and services have allowed governments to provide a new way to deal with citizens and businesses through mobile platforms. The demand for better, more efficient and more effective government services will put serious pressure on the government with regard to m-government (i.e. transparency, access, affordability, and participation) (Rossel, Finger & Misuraca 2006). M-government can be seen as a subset of e-Government (El-Kiki & Lawrence 2006; Ntaliani, Costopoulou & Karetsos 2008). m-Government is defined as:

> The strategy and its implementation involving the utilisation of all kinds of wireless and mobile technology, services, applications and devices for improving benefits to the parties involved in e-Government including citizens, businesses and all government units (Kushchu & Kuscu 2003).

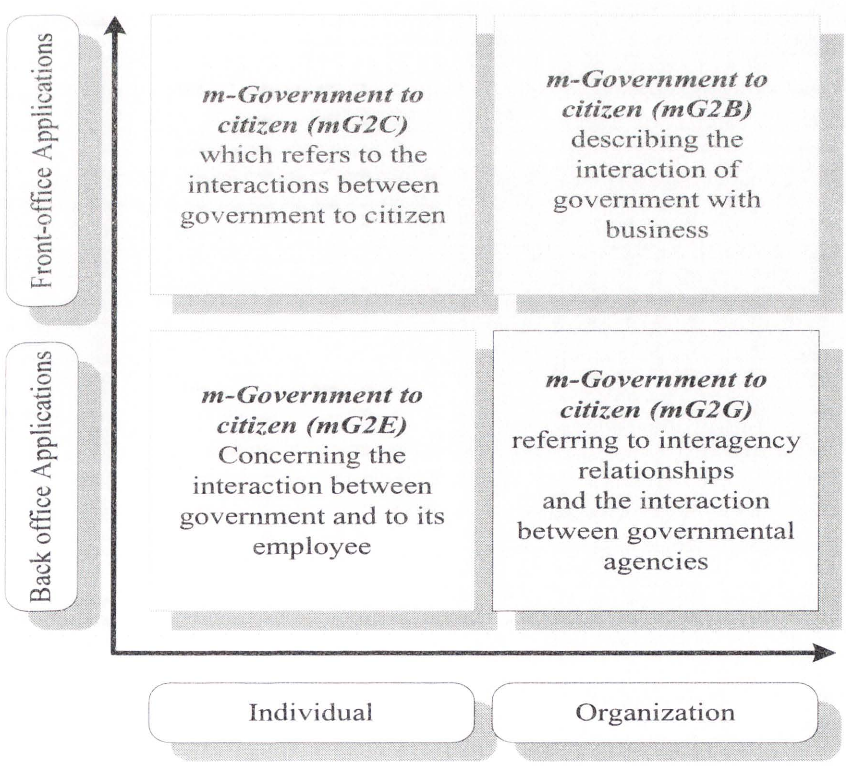


Figure 2.2: Types of m-Government services

According to (Kim et al. 2004; Saldhana 2007), four main types of m-Government services are identified and categorised as illustrated in Figure 2.2: Government to Government (G2G), Government to Employee (G2E), Government to Citizens (G2C), and Government to Businesses (G2B). This study mainly focuses on the G2C category but also involves some part of G2G.

2.3.1 m-Government Services

m-Government applies to four main dimensions in the public sector as illustrated in Figure 2.3.

- **m-Communication**: Providing information to the public is not a trivial activity. It is the foundation of citizen empowerment. Without relevant information, citizens are unable to form intelligent opinions and, thereby, are unable to act on the issues before them meaningfully.

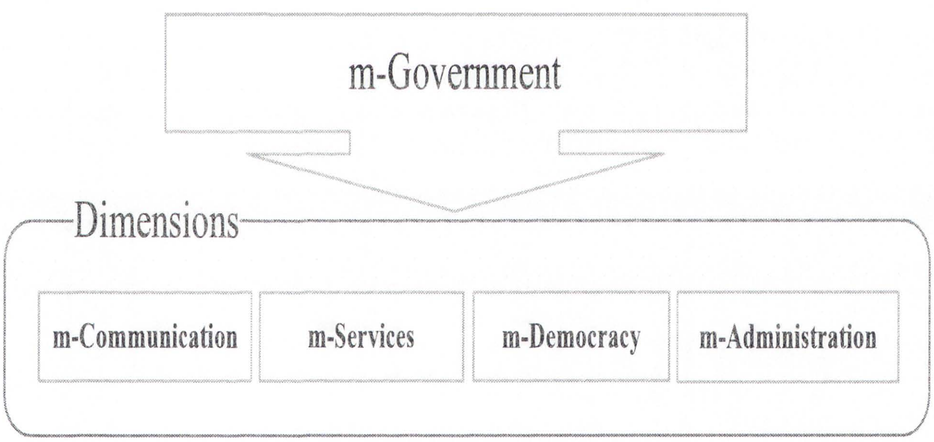


Figure 2.3: m-Government dimensions

- **m-Services:** Providing a channel of communication between citizens and government via SMS, and enable G2C transactions as well. Some examples of existing m-Services mobile parking (m-Parking), m-Teacher: m-library and crisis communication.
- **m-Democracy:** m-Voting and the use of SMS and mobile devices for citizen input to political decision-making is an m-Government application with tremendous potential to enhance democratic participation.

- **m-Administration:** m-government also provides opportunities to improve the internal operation of public agencies.

As stated in (Trimi & Sheng 2008), there are various examples concerning each type of m-Government services. For example, in Canada, the government enables the citizens to access government information using mobile devices. In San Francisco Police Department-USA, Police officers can use mobile devices to access databases, issue tickets, check vehicle registrations and license tags. In Sweden, numerous mobile phone-based services have been launched in the country, including SMS applications for city job postings, parking fee payments system, government inspector service, tax services, and mobile healthcare providers. Table 2.2 lists some examples m-Government applications in Asia, North America and Europe.The MERS proposed in this study is an m-service that aims to provide a new function and service of m-Government.

Table 2.2 Examples of m-Government applications (Trimi & Sheng 2008)

	Applications	Government Agencies	Description
Government-to-Citizen (G2C)	SMS alerting services	Police department, London, UK	Inform citizens about security threats and emergency alerts
	Mobile tracking systems	Metro line, London	Track buses using mobile communication systems Send messages to control traffic flow
	SMS job postings	Sweden	Provide job posting for temporary workers via SMS
	Tracking election returns	Commonwealth of Virginia, USA	Allow individuals to track election returns for state wide races on election night
	Emergency notification	Federal Aviation Administration (FAA), US	Provide real-time airport status information via email
	SMS alerting services	Hong Kong	Send text messages to mobile phone users during SARS
	SMS notifications	Singapore	Provide parking ticket reminders, national service obligations and passport

			renewal notification
Government to Employee (G2E)	Tracking suspects	Police department, Germany	Track suspects' movements using GPS and mobile phones
	M-parking	Police department, Austria	Allow officers to retrieve information using mobile devices
	M-Police	Korea	Allow officers to print tickets on the spot
	M-local tax management system	Korea	Allow officers to access tax information on the spot and transfer the data to the local tax database

2.3.2 Benefits and Challenges of m-Government

Recently, mobile and wireless technologies are playing the central role for communications to expand local government economics, increase public safety and establish good relations with citizens and businesses. Mobiles and wireless technologies are also increasing productivity and efficiency within government agencies (Blackman 2006). m-Government expands the scope of e-Government because it offers the following advantages:

- **m-Government improves the delivery of government information and services**. Government uses the accessible and rapid mobiles and wireless technologies to send time-sensitive information such as emergency alert to citizens on an anywhere-anytime basis.
- **m-Government increases the efficiency and effectiveness of government employees**. Communication through mobile devices enables employees to access the information required and make up-to-date decisions and activities in real time.
- **m-Government increases the channels for public interaction.** m-Government applications may become a key method for helping remove wired infrastructure constraints, reaching citizens far and wide and supporting exchange of communications.

- **m-Government can be a more cost-effective channel**. Communication through mobile devices is a more economical choice for countries with compact populations and difficult landscapes. For example, more than 90 per cent of Macedonia's population use a Wi-Fi mesh network that covers 1,000 miles for $12 a month.
- **m-Government increases the productivity of governmental agencies**. e-Payment application has been used in India by some governmental services to avoid corruption.

Finally, m-Government appears to be a promising solution for government agencies to communicate with their citizens. For instance, citizens express their points of view to government officials, politicians and community representatives through mobile devices.

However, as with any technology, the implementation of m-Government services also brings a number of issues. Some of these issues shared with e-Government implementation, such as limited processing and memory capacity, privacy and security, cost and lack of financial resources, staff and expertise, acceptance (El-Kiki & Lawrence 2006), infrastructure development, accessibility, legal issues, and compatibility (Kushchu & Kuscu 2003). Some of these issues will be discussed in Chapter 3.

2.4 Emergency Response Systems

Emergency response systems are used by organisations to assist decision makers in responding to an emergency situation. These systems support communications, data gathering, data analysis, and decision-making of emergency response. They are rarely used but when needed, must function well and without fail (Phillips 2005). Due to the increasing threat of terrorist attacks, the need for effective emergency response systems has been recognised worldwide (Chen et al. 2005). Emergency response demands fast and effective action. It requires collaboration between numerous people and groups (Morten, Esben Toftdahl & Margit 2006).

2.4.1 Traditional Emergency Response Systems

Canadian residents and US use the three-digit telephone number 9-1-1 (0-0-0 in Australia and 1-1-2 in Europe) for reporting emergencies and requesting police, fire, medical assistance, and rescue services. This emergency way is based on two communications models: 1) many-to-one, a telephone-based emergency report system and 2) one-to-many, a top-down aid distribute system (Wu et al. 2007). The advantages of the traditional way (9-1-1 phone system) include easy remembering number to call, for help in an emergency, all calls to the system are free, and all type of emergency resources immediately available.

In the mid-1980s, Enhanced 9-1-1, or E9-1-1 was developed. E9-1-1 was designed to provide the PSAP with the phone number and location of the calling party. At the heart of the E9-1-1 system are databases for determining both the location of a call and the nearest public safety answering point (PSAP), and a robust routing system to carry the call to that PSAP. These rely on Automatic Number Identification (ANI) and Automatic Location Identification (ALI). The system as a whole is generally referred to as the ANI/ALI system (Phillips 2005).

Small-scale and local environmental emergency events can usually be handled by public emergency services, but large-scale environmental emergencies such as strong earthquakes, extensive flooding, biochemical attacks or severe nuclear radiation evacuations, are more complicated situations that can block and disable the phone system. Clear and immediate communication is vital to effective response (Bahora et al. 2003; Kim et al. 2008; Liu 2004).

Another challenge for the 9-1-1 services is that wireless and VoIP networks have problem to transmit location data in a standard manner, because VoIP users can log on to the Internet from any location in the world, calls to 9-1-1 can originate where there is no fixed location for the caller (Korzeniowski 2005; Shaw 2006).

However, users of mobile phones that are Global Positioning System (GPS)-supported may turn off the positioning facilities. Similarly, the phone number may is blocked (i.e.

the number does not appear on another phone display). Consequently, no phone number appears on the 9-1-1 screen when the cell phone user makes an emergency call (Futch & Soares 2001), therefore, the caller location cannot be tracked.

2.4.2 Web-Based Emergency Systems

Many applications have showed that ICT are critical to improve response to disasters. The Internet is emerging as potential source of information about a particular disaster. Emergency responders now have the ability to access to this enormous data via web pages (Robinson & Donald 2005). This section examines the concepts and methods relating the web-based emergency response systems.

Many emergency notification systems (ENS) exist and are used to notify people by phone or e-mail or through websites. Some systems also permit the delivery of messages to pagers and SMSs. Table 2.3 summaries some of the ERS systems that are used by private companies, schools, government offices, Red Cross, fire-fighters, police, as well as many other institutions. Service technologies provided by these systems are almost all based on websites, phone, and SMS.

The system in Table 2.3 was used to evaluate whether existing ERSs support decision makers. After surveying the systems exist, it was found that these systems only provide SMS notifications (i.e. no two-way communication), and they have some weakness in decision support, especially for man-made disaster situations. Further, the ENSEMBLE system only assists decision makers and scientific advisors in the management of nuclear emergencies. It can also be concluded that these systems do not provide notifications in a way that considers people's needs, nor do they consider information related to previous disaster situations to provide effective emergency notifications. This can be done by providing decision makers with knowledge that reflect the experience (CBR in this case).

Table 2.3: Web-based emergency notification system

System	Web	Type	Delivery	Decision support
Honeywell	https://instantalert.honeywell.com/	Alert	Mobile pager, PDA, and e-mail	No
MissionMode	http://www.missionmode.com	Emergency notification system	land-line or mobile phones, email, SMS text messages, pagers or faxes—all from a single web page	No
ENSEMBLE	http://ensemble2.jrc.ec.europa.eu/	Web-based decision support system	Web pages	Yes
Command Caller	http://www.voicetech.com/ Command_Caller_40.htm	Emergency, situational alarm, alert	Phone, E-mail, Pager, Fax, SMS,PDA	No
Sahana	http://www.sahana.lk/	Emergency	Web pages	No
Arce	https://arce.dei.inf.uc3m.es/ arce_demo/	Emergency, situational alarm, alert, system status	Web pages, E-mail	No
AlertFind	http://www.messageone.com/ crisis-communications/	Emergency, situational alarm, alert	Phone, E-mail, Pager, Fax, SMS, PDA	No
Sigame	http://www.sigame.es/	Emergency	Web pages	No

Therefore, as stated in (Heidi et al. 2007), independent evaluations of free and open source software (FOSS) (e.g. SHANA) deployments are required in order to judge whether the platform has played a significant role in any given response. There is a number of challenges facing FOSS as declared in (Mansourian et al. 2006) such as limited access to fundamental public data and lack of financial support. The participation of organisations is required to ensure a successful deployment and to maintain appropriate solutions to the end users.

2.5 IE and Aggregation

2.5.1 Definition of IE and Aggregation

The following examples are used to define and understand the IE concept. A government is looking for a summary of the latest data available about a natural disaster happened in the last five years. The second example is about investigating general trends in terrorist attacks all over the world. A government has a huge database of news and emails and wants to use theses to obtain a detailed overview of all terrorist events and natural disasters in a particular region. These two different examples shared the following points:

- the request for information
- the response to this request is usually present in unstructured data sources such as text and images
- it is impractical for humans to process large amounts of data
- computers cannot be directly queried for unstructured data format.

To solve these problems, IE is a significant research field within the Artificial Intelligence (AI) area, for its efforts to extract related information out of huge amounts of data (Soysal, Cicekli & Baykal 2010; Yildiz & Miksch 2007; Zhou, Qian & Fan 2010). IE refers to 'a technology for finding facts in plain text, and coding them in a logical representation such as a relational database' (Roman et al. 2005; Zhou, Qian & Fan 2010). Moens (2006) sees IE as:

> The identification, and consequent or concurrent classification and structuring into semantic classes, of specific information found in unstructured data sources, such as natural language text, making the information more suitable for information processing tasks.

IE consists of five major subtasks:

- Segmentation finds the boundaries of the text snippets that will fill a database field.
- Classification determines which database field is the correct destination for each text segment.

- Association determines which fields belong together in the same record.
- Normalisation puts information in a standard format in which it can be reliably compared.
- De-duplication collapses redundant information so you do not get duplicate records in your database.

Aggregation aims to combine a finite number of observed values into a single output (Zhu, Siegel & Madnick 2001). Many aggregation operators have been developed to aggregate information with a wide range of properties. There are various linguistic operators and it is not a simple task to select a suitable operator for a particular system (Li, Zhou & Huang 2009; Saha et al. 2010).

2.5.2 Extraction Methods

The method used for IE is classified into two dimensions categories: Hand-coded or Learning-based and rule-based or statistical (Sarawagi 2007).

2.5.2.1 Hand-Coded Method

e hand-coded method requires human experts to define rules or regular expressions for carrying out the extraction. The hand-coded method depends on more deeply linguistics, external ontologies and context (Nédellec & Nazarenko 2005).

2.5.2.2 Learning-Based Method

Learning-based method requires manually extracted labelled unstructured template that contain pre-specified types of events for training. A learning-based system use less linguistic analysis and simpler representation. The bag of words (BOW) is a common model for representing a text in a learning-based system. The BOW model is based on a vector representation of a text (Cohen & Hunter 2004).

2.5.2.3 Rule-Based Method

A rule-based method requires a collection of rules, and a set of policies that control rules. A basic rule is of the form: 'Contextual Pattern → Action'. A contextual pattern represents one or more labelled patterns capturing various properties of entities in the text. A labelled pattern is a regular expression defined over features of tokens in the text. The features reflect any property of the token in which the token appears. The action refers to assigning an entity label to a sequence of tokens (Sarawagi 2007).

2.5.2.4 Statistical Method

The statistical method uses a statistical model to make decision if a candidate information is present in a given text (Blohm 2011). The statistical method converts the unstructured text into a decomposition form. The most popular form of decomposition is into tokens and then assign label to each token. The tokens are obtains by dividing an unstructured text along a predefined set of delimiters. A second form of decomposition is into word chunks. A natural language parsing technique is a commonly used for creating text chunks via identify noun chunks in a sentence (Sarawagi 2007).

There are several tools currently addressing the implementation of IE system. Some of those tools are listed below:

- GATE
  http://gate.ac.uk/
- ReVerb
  http://reverb.cs.washington.edu/
- Ontotext
  http://ontotext.fbk.eu/portal.html
- ANNIE
  http://www.aktors.org/technologies/annie/

The statistical method has been selected to use in information extraction of EMRS system. A maximum entropy statistical model has been used to extract information from text. A maximum entropy statistical model is more appropriate, robust to noise in the unstructured data, and offers a clean way to estimate the probability of certain token occurring with a certain SMS text. This model will be discussed in Chapter 3.

2.6 CBR Approach

The case-based reasoning (CBR) approach is one of popular methodologies in knowledge management (KM) (Niu, Lu & Zhang 2008), and an intelligent method for using appropriate previous experience to solve new problem by reusing information and knowledge of that situation (Wu, Lo & Hsu 2008; Yang et al. 2009). CBR has been broadly applied in various areas such as medicine (Holt et al. 2005) to enhance the quality and efficiency of treatment, e-commerce (Sun & Finnie 2004; Yanhong et al. 2007) to improve the performance of recommender systems, finance (Oh & Kim 2007) to monitor financial market against its possible collapse, oceanographic(Fdez-Riverola & Corchado 2003) to forecast parameters of a complex and dynamic environment in an unsupervised way, and engineering aspect for product design such as prediction, quality analysis and data mining.

Recently, the field of CBR has received more research attention in the subfield of artificial intelligence (AI) (Castro et al. 2011; Liu, Chen & Hsu 2008). CBR has been combined with various AI techniques. Multi-agent mechanism brings flexible for CBR. It enhances the capability of solving complicated question in new system, and overcomes the shortcoming of the fault knowledge difficult to update in traditional systems. Link CBR and Artificial Neural Network (ANN) have also been used to solve potential lawsuit problems caused by changing orders in construction projects (Chen & Hsu 2007). A fuzzy CBR technique has also been used for classification applications (Chang et al. 2010). Genetic Algorithm (GA) is one of the most popular applications of CBR. It has been used to improve the design of retrieval methods and the accuracy of CBR system (Shiu and Pal 2004).

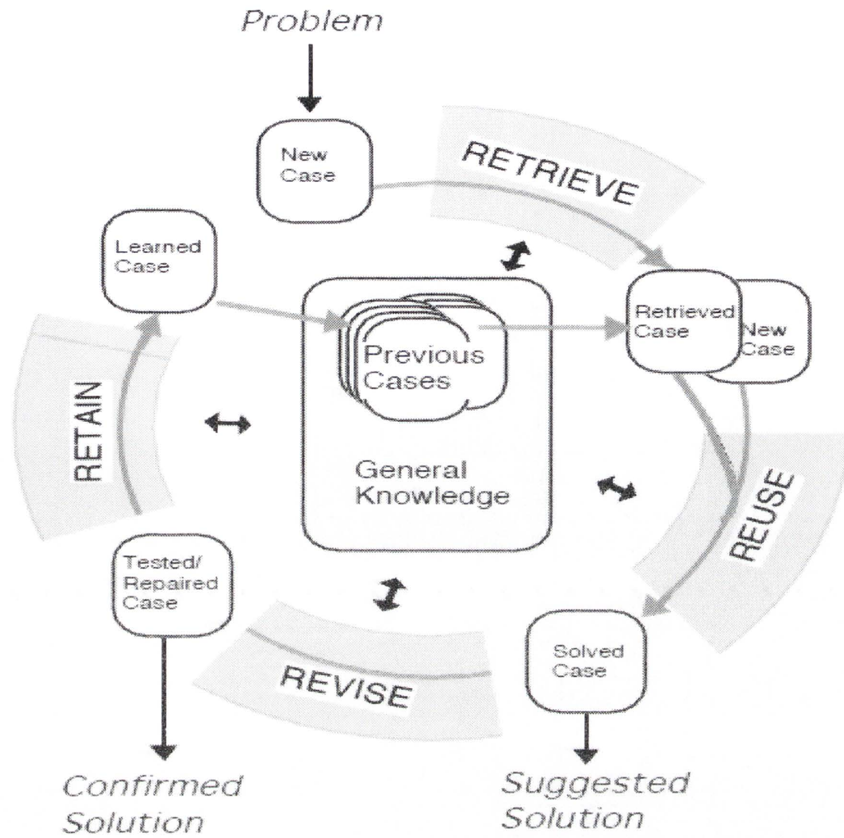


Figure 2.4: A typical CBR lifecycle

The problem solving cycle in CBR consists of four main phases, as shown in Figure 2.4 (Richards & Ekárt 2010):

1. **Retrieve phase:** This retrieves cases that are the most relevant matches for the given input case information.
2. **Reuse phase:** An appropriate knowledge base is used to modify the process sequence, new tasks may be added or deleted and constraints may be reconfigured.
3. **Revise phase:** This involves mapping the previous solution to the target situation, and testing the new solution in the real world (or a simulation).
4. **Retain phase:** The resulting experience is stored as a new case.

A case is the primary knowledge-based element in a CBR application with three parts: problem description; solution; and outcome (Fang & Wong 2010; Zhao et al. 2009). The case representation is one of the most important task in CBR system, and should include specification of the problem and the relevant attributes that has direct impact on the situation outcome (Sun & Finnie 2004). For example, in the case terrorism disaster has often provided the essential information for situation assessment, such as the category of disaster, disaster location, as well as potential damage. The case representation can be viewed as the task of enabling the computer to recognise, store, and process past experiences. Case representation and indexing can be conducted by using a wide range of representation forms, including frames, semantic nets, rules and relational database techniques. A tuple-based case representation is driven from relational database technology rule-base representation is driven from rule-based technology, and object-oriented case representation is driven from object-oriented technology. These three kinds of case representations are fundamentals for building a case base in CBR system (Sun & Finnie 2004).

The benefit of using CBR approach is to let the retrieving process more convenient in disaster situation in order to depict conclusions and to give recommendations based on the knowledge from the past disaster event occurs. More details will be discussed in Chapter 4.

2.7 Ontology

This section briefly sets out recent research development and results on literature of otology. Specifically, it reviews the ontology definition and ontology development process.

2.7.1 Ontology Definition

The term ontology is derived from philosophy, where it tries to answer question on what can exist and what are the essential things in the world. Many definitions of ontology have been defined depending on communities (Larsen et al. 2006). In the computer science field, the term ontology stands for a structured framework for the representation of information and knowledge (Morbach, Wiesner & Marquardt 2009).

Ontology has been defined as the 'specification of conceptualisation'. Another definition has been given by (Noguera et al.) 'a set of classes or concepts, the relationships between them and constraints on these relationships to restrict the set of their possible interpretations'. Ontologies provide knowledge sharing, reuse, and common understanding that reaches across people and application systems (Fensel et al. 2001). Ontologies are classified according to their level of dependence on a particular task or point of view including (Conesa, Storey & Sugumaran 2010):

- Upper-level (or generic or reference) ontologies contain massive amounts of knowledge about the real world and are independent of a particular domain.
- Domain ontologies provide a concept for specific domains and in a specific way.
- Application ontologies describe concepts relative to a task domain such as reasoning process for medical diagnosis.

There are various standard ontology languages to represent ontology such as Web Ontology Language (OWL) for the Semantic Web, developed by the World Wide Web Consortium (W3C) Web Ontology Working Group. OWL provides three increasingly expressive sublanguages (Lite, DL and Full), designed for use by specific communities of implementers and users (Ebrahimipour, Rezaie & Shokravi 2010; Noguera et al. 2010). The Resource Description Framework (RDF) Schema (Brickley & Guha 2004; Zhang, Li & Tan 2010) provides essential vocabularies to describe domain knowledge, the essential common model for data aggregation and integration. DAML+OIL is a sufficiently expressive and flexible service description language to be used to describe the resources on web (Trastour, Bartolini & Preist 2003). To speed up ontology development, several ontology development tools have been proposed such as editing tools, ontology merging tools and ontology extraction tools (Park, Cho & Rho 2010). Ontology editing tools (e.g. Protégé) have been developed to access, manage, and visualise domain knowledge of ontology. Ontology merging tools are used to create a single logical ontology by combining two or more existing ontologies (e.g. PROMPT). Ontology extraction tools aim to automatically generation of ontologies from linguistically annotated text collections by applying some techniques such as natural language processing or machine learning (e.g. Text-To-Onto).

2.7.2 Ontology Development Process

This section describes the steps of the domain ontology development process as shown in Figure 2.5. At each stage, there are activities to be implemented.

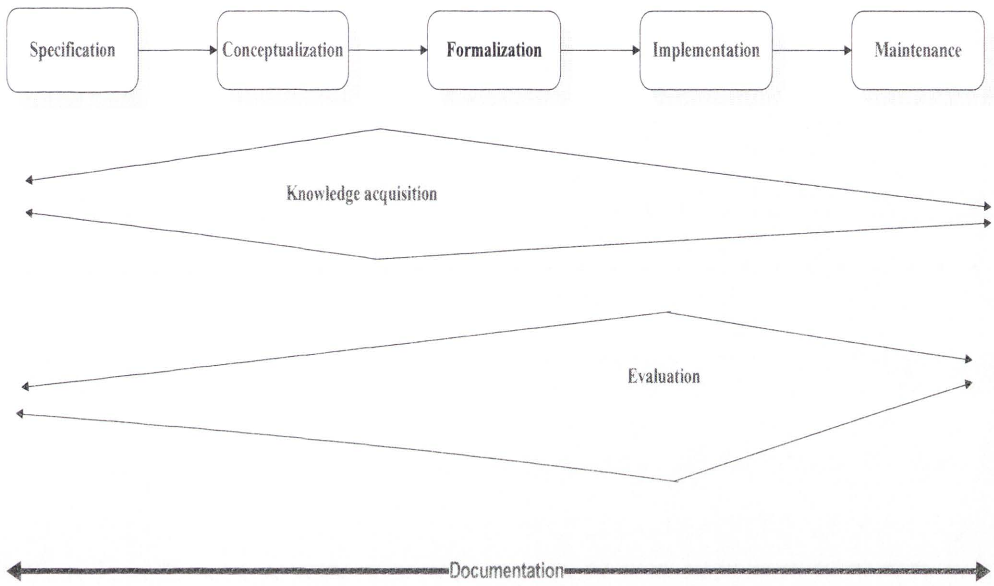


Figure 2.5: Ontology life cycle process (Pinto & Martins 2004)

- **Specification:** In this stage, identify the purpose and scope of the ontology.
- **Conceptualisation:** Define a conceptual model to meet the specification initiated in the previous stage. The conceptual model of ontology consists of concepts and relationships among those concepts.
- **Formalisation:** Transform the conceptual model of ontology defined in the previous stage into a formal model. In this stage, the developer constructs the basic concept hierarchy based on the application users requirements through a structuring relation, such as is-a (class-superclass, instance-class) or part-of, and define properties of those classes
- **Implementation**: Implement the formalised ontology in a knowledge representation language such as OWL.
- **Maintenance:** Update and correct the implemented ontology.

- **Knowledge acquisition:** Use several techniques to acquire knowledge, such as brainstorming, interviews, questionnaires, text analysis, and inductive techniques.
- **Evaluation:** Use technical criteria to verify the quality of the ontology, using competency questions and real-world validations.
- **Documentation:** Report to describe the ontology building process

2.8 State of Research

Recent research shows that m-government is the new frontlines of the development plan that need to be highlighted by the development community. Governments should take advantage of the mobile technologies and start providing simple informational and interactive services, such as providing brief information relating to disaster situation via Short Message Services (SMS).

The rapid development of mobile technologies has enabled governments to transit from e-Government to m-Government. This research is focus on the applications of mobile technologies in the public sector, particularly in the area of emergency response system.

In an emergency response system, mobile technology can be used to link citizens, businesses, and non-profit organisations. For example, in an emergency situation such as the 9/11 terrorist attack, mobile technology can be used to enhance productivity, to provide rapid connectivity and disaster response, and to facilitate rapid access to information on an anywhere-anytime basis. This then provides the focus for the research into an emergency response system within m-government.

2.9 Chapter Review

The literature review described important aspects of m-government, emergency response system. The importance of delivering government information and services to citizens quickly and directly was identified.

Studies show that emergency responders have the ability to access an enormous amount of data via website applications. The extent to a mobility in which these applications actually motivate improvements in emergency response was not sufficiently determined.

This chapter argued that m-Government and emergency response systems need to be addressed in the development of m-Service applications by identifying the concepts of emergency response system and its relevant frameworks, algorithms, models, and by applying them to m-government environment.

To summarise, m-Government has demonstrated great inevitable direction of development of e-Government, and shown a promising future. There is no doubt that mobile-based emergency response system will be a part of the trend of m-government. The current literature concentrates on the web-based application developed in response to the disasters. This provides opportunities to develop an intelligent framework to provide help information to the government and citizens particularly in the area of emergency management related to man-made disasters and public safety through a mobile communications. The literature review also described important techniques that to be used for a mobile-based emergency response system.

Chapter 3: An MERS Framework

Emergency Response Systems are rarely used but when needed, must function well and without fail.

Phillips (2005)

This chapter presents an MERS framework that has five main components—register, monitoring, analysis, decision support and warning—aiming to provide a new function and service to m-government. The proposed framework would also offer a new opportunity for interaction among government, citizens, responders, and other non-government agencies in emergency situations.

Studies show that mobile-based information systems can be a solution to benefit first responders in a variety of ways. First, the mobility devices allow first responders to perform better rapid and actionable decision making. Second, a development of wireless/mobile technology and communication trends provides a ubiquities environment for deployment within a variety of fields (Kim et al. 2008). In addition, using mobile devices will create interactive communication mechanisms that can facilitate just-in-time communication and collaborating among large number of residents and responders (Paul et al. 2007). The MERS makes the use of mobile technologies to assist government to get information and make decisions in response disasters. However, with this way, every mobile user has the ability to report emergency information and to access fast information that may save his/her life. This research mainly considers the situations of man-made disasters, including bomb attacks; non-natural events; fire; chemical attacks and hijacking, which share some common features in responding system development.

In this chapter, the MERS conceptual framework and the different components of the MERS are discussed. A MERS technical framework is also developed and presented, including disaster management, applications, organisations and system boundaries(Amailef & Lu 2011). The organisation of this chapter is explained in Table 3.1.

Table 3.1: Organisation of Chapter 3

3.1	Conceptual Framework 3.1.1 MERS components 3.1.2 Disaster Management 3.1.3 Disaster Organisations 3.1.4 Risks and Risk Management for an MERS
3.2	An MERS Technical Framework 3.2.1 MERS Applications 3.2.2 System Boundary
3.3	Cases in an MERS 3.3.1 Information Extraction and Aggregation Application 3.3.2 Ontology-supported CBR for MERS
3.4	System Evaluation
3.5	Chapter Review

3.1 Conceptual Framework

The MERS proposed in this study is an important new m-Service under the m-Government platform, aiming to provide a new function and service of m-Government (Amailef & Lu 2008). It is designed to help people obtain assistance from and provide information to the government in an emergency situation.

3.1.1 MERS Components

The MERS conceptual framework proposed in this study consists of four main components: inputs, processes, outputs and outcomes as illustrated in Figure 3.1.

- **Inputs:** elements to enter into the system. Examples of inputs are a mobile user's details and emergency request data
- **Processes:** all the elements necessary to convert or transform inputs to outputs. For example, a process may include disaster monitoring, and data analysing

- **Outputs:** the consequences of being in the system. For example, warning messages
- **Outcomes:** can take any or both of two forms benefits and/or risks, each should be well planned.

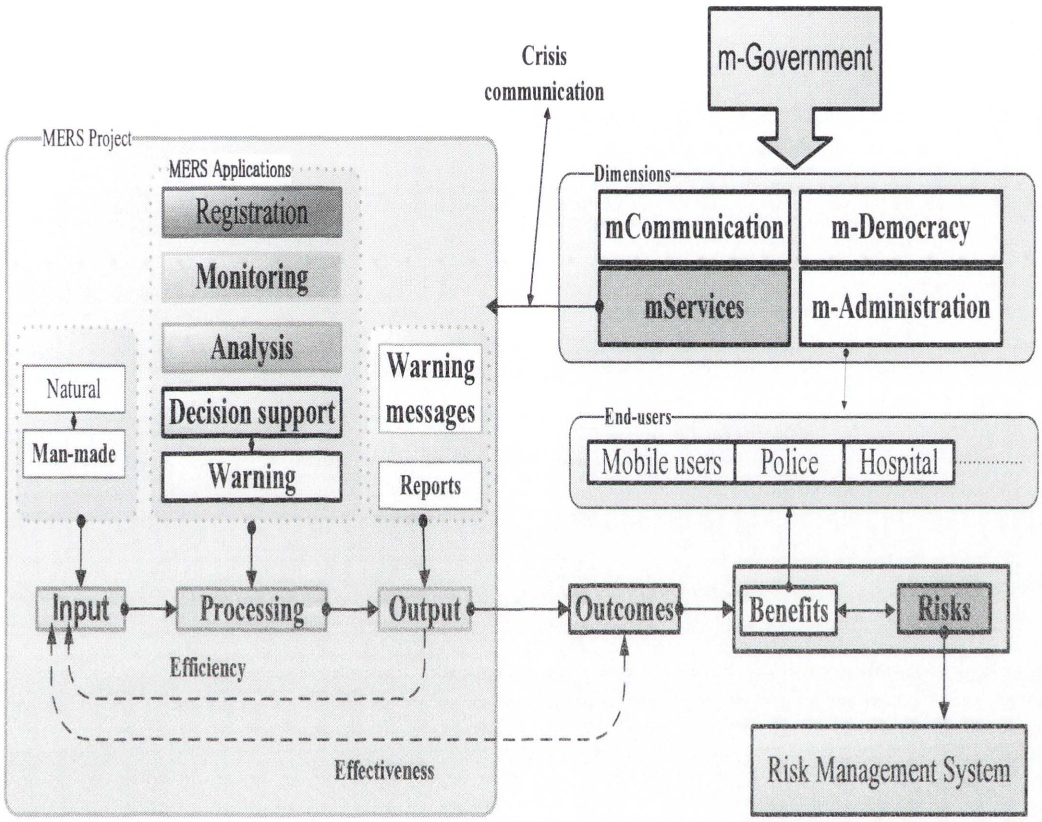


Figure 3.1: Emergency response system with an m-Government dimension.

3.1.2 Disaster Management

A disaster is defined as 'a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources' (ISDR 2004).

Emergency response agencies have to respond to two various categories disasters. In this study, the part mainly deals with man-mad disasters such as large-scale terrorism, a chemical spill, nuclear radiation escapes, utility failures, epidemics, crashes, explosions, and urban fires (Lallana 2004). It is in charge of disasters specifications and their impacts.

3.1.3 Disaster Organisations

There are numerous organisations involved in emergency response. As stated in (Robinson & Donald 2005), the objective of an emergency response system to a disaster is to minimise the impact of a disaster on several organisations. The main organisations involved in an emergency response system include residents, government agencies, businesses, volunteer organisations and experts. In a major disaster such as the 9/11 terrorist attacks and Hurricane Katrina, information sharing and incompatible technology are significant issues for all those organisations involved (Paul et al. 2007). This component will store information on a variety of organisations involved in a disaster situation.

3.1.4 Risks and Risk Management for an MERS

According to (Aubert, Patry & Rivard 2005), risk and risk management have been attentively studied in a variety of fields, such as Insurance, Economics, Management, Medicine, Operations Research and Engineering. Each field addresses risks based on its object of analysis, (Mees 2007) defines risks as 'the chance of something going wrong as a result of a hazard or a threat which has an impact on operations'. In order for the government to use a MERS system, an effective a risk management framework should be exists. Risk management should therefore have the ability to deal with a new and changing knowledge as the system proceeds (Roy 2004).

3.1.4.1 MERS Risks

A MERS risks represent another type of pressure on m-Government organisation. An MERS system is an m-Service that will bring a series of challenges shared by other m-government efforts. Like many innovations, wireless services may present as many challenges as potential solutions (Moon 2004). Therefore, the implementation of m-government services also brings a number of challenges. Some of these issues shared with e-Government implementation, such as privacy and security, infrastructure development, accessibility, legal issues, and compatibility. This section identifies the basic requirements or factors that need to be taken into account when building a MERS services. These factors are identified in the following four areas: Organisational Characteristics, Human Capacity, Financial Capacity, and Technical Infrastructure.

The main objective of this MERS system is to let interaction between citizens and their government in an emergency situation, which is mainly composed of registration services, monitoring services, analysis services, decision support services, and warning services for effectively returning citizens the most accurate information. To meet this objective, our MERS system should take the following requirements into consideration (see Figure 3.2): limited processing and memory capacity, privacy and security, cost and lack of financial resources, staff and expertise, acceptance (Fensel et al. 2001), infrastructure development, accessibility, legal issues, and compatibility (Antovski & Gusev 2005; Kushchu & Kuscu 2003).

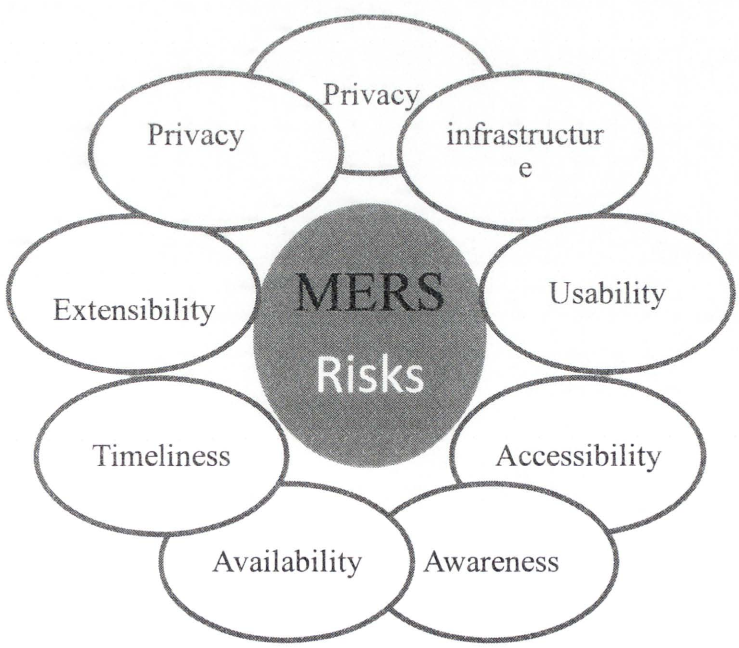


Figure 3.2: MERS risks.

- **Infrastructure development:** A MERS requires significant investment infrastructure. Both physical and software infrastructure must be at an acceptable level. Physical infrastructure stands for the equipment required for implementation of a MERS system. Software infrastructure stands for all software that makes a MERS system possible.
- **Privacy and security**: In order to clearly identify the kind of protection of implementing MERS system, a security aims to maintain the following principles
    - **Confidentiality**: protect information from unauthorised users
    - **Integrity**: protect information from corruption or changed in any way
    - **Accountability**: guarantee that the identity of mobile users is keeping its security promises
    - **Availability**: guarantee that the MERS system is available and function properly
    - **Accessibility**: securing or making the MERS system open to a wider user population.
- **Awareness:** Awareness in a MERS system refers to communicating a MERS services to appropriate users and provides ways in which they can contact and access the service.
- **Usability:** The MERS services can be reached with a minimum accessibility and high quality level (i.e. the services are easier and more convenient to use).
- **Timeliness:** This guarantees that the MERS services are delivered on promised time.
- **Trust:** Trust has been identified, as 'an essential element of a relationship when uncertainly or risk is present'. Therefore, lack of trust in an MERS services can prevent mobile users from using mobile services.
- **Scalability & Extensibility:** The MERS services need to be simple, reconfigurable, scalable and easily extensible. This ensures that MERS services are delivered to a large number of citizens, with an acceptable quality of service.

3.1.4.2 Risk Management

The complexity of government agencies and emerging of a new technology will introduce more risks, which may add to its complexity (El-Kiki, Lawrence & Steele 2005). Risk Management (RM) system is required to guarantee effectiveness, efficiency, flexibility and transparency. The purpose of RM system is to provide a generic method to defined, implement, and improve the MERS project processes. Moreover, it provides the public organisations with appropriate support in the planning and management phases and it guarantees integration between different projects carried out in the area of m-Government project. These goals can only be achieved through an effective management system or framework. RM frameworks set out the relationship between the processes of risk identification, evaluation and management. To meet MERS requirements, Figure 3.3 is an adaptation of a Management Response Framework from (El-Kiki, Lawrence & Steele 2005) to assist the analysis of MERS services with a recursive relationship between input and output.

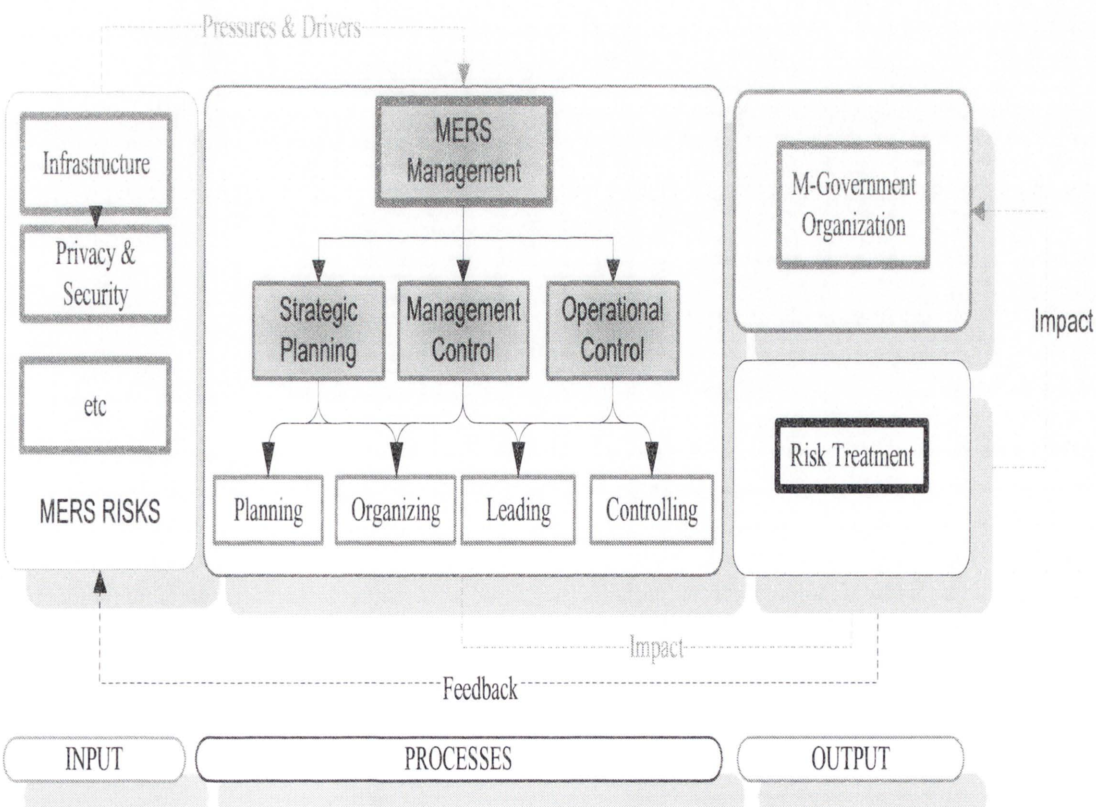


Figure 3.3: Management response framework for MERS application

3.1.4.3 Processes

The processes represent the major categories activities carried out in an organisation. The framework of planning and control system suggested by is used to control classification of control organisation activates. In this framework, there are three levels of planning activities:

- Strategic planning is the process of deciding on the goals, the priorities, the direction and the policies of the organisation.
- Management control is the process by which managers assure that objectives, resources, motivation, and regulation are obtained to meet the organisation's objectives.
- Operational control is the process of assuring that tactics, tasks, incentives and measures are performed effectively and efficiently.

There are four management concepts that allow any organisation to handle strategic planning, management control, and operational control. The four basic functions of the management should be planned in order to reach organisation goals and objectives. The four functions of management that form the foundation of a MERS management include planning, organizing, leading and controlling.

3.1.4.4 Output

The consequences of being in the management process can take the form of risk treatment. Risk treatment aimed at getting the best response option to the identified risks, assessing those options, and preparing risk treatment plan (Samy, Ahmad & Ismail 2010). The process of identified risks is used to generate a comprehensive list of events, identify possible causes and scenarios that might affect organisational for additional analysis. This process is also used to provide appropriate tools and techniques for risk identification. Once risks have been identified and assets, there are four major approaches to handle a risk. These approaches are avoidance risk, reduction risk, sharing risk, and retention risk (Bønes et al. 2007; Cavalli et al. 2004; Gary, Alice & Feringa 2002):

- **Avoidance risk:** to avoid the risk by eliminating the risk cause and/or consequence (i.e. not the things that could lead to the risk)
- **Reduction risk:** reduce the risk to an acceptable level by implementing supporting, preventive, and detective controls that minimise the likelihood of risk
- **Sharing risk:** to transfer the risk to a third party to compensate for the loss, such as purchasing insurance
- **Acceptance risk**: to accept the potential risk and continue operating the system. These are the risks that are low enough to be acceptable.

Table 3.2 summaries a common approach relevant to risk management. As an example, reduction risk means to accept a risk that comes from an unlikely treat, even if it could have a high impact.

Table 3.2: A possible risk management strategy

Impact	Likelihood	
	High	Low
High	Acceptance risk	Reduction risk
Low	Sharing risk	Avoidance risk

The goals and tasks of an organisation should be considered in selecting any of these risk management approach. It may impractical to address all identified risks, so priority should be given to the risks that cause significant task impact or harm.

The evaluation of risk depends on hazard, exposure, location and vulnerability factors. The risk can be formulated as follows (Wu, Lo & Hsu 2008):

$$R = H \times V \times E$$

Where R: disaster risk

H: ratio of disaster occurrence

E: exposure of persons or property to the disaster

V: damage level

Table 3.3 summaries the risk levels based on the acceptance criteria. Four main risk levels were defined: insignificant, low, moderate, and high. For instance, the risk level high is classified as an unacceptable risk. This risk level must be treated in order to have its risk reduced to an acceptable level based on the risk acceptance criteria.

Table 3.3: Definitions of values for risk level (Bønes et al. 2007)

Risk level	Description
Insignificant	Acceptable
Low Acceptable risk.	The service can be used with the identified threats, but the threats must be observed to discover changes that could raise the risk level
Moderate	Can for this service be an acceptable risk, but for each case it should be considered whether necessary measures have been implemented
High Not acceptable risk.	Cannot start using the service before risk reducing treatment has been implemented

3.2 An MERS Technical Framework

An MERS technical framework is developed and presented in Figure 3.4, which includes disaster management, applications, organisations, and system boundaries. This section will focus on MERS applications and explain them in details.

3.2.1 MERS Applications

The MERS support five major modules as illustrated in Figure 3.4 as its application components.

3.2.1.1 Registration Application

This application keeps tracks of all entities of interest in the disaster area such as relief organisations, experts and mobile users. The information includes mobile user's personal details; the data includes a comprehensive list of expert's relief organisation, and volunteers organisations. In addition, it captures the essential services of each organisation.

3.2.1.2 Monitoring Application

This application constantly monitors crisis and quickly reports in charge of analysis module. On other words, the module is collecting complete and accurate disaster data via mobile communication devices.

3.2.1.3 Analysis Application

The functions of this application are to support crisis classification, identifying related experts to contact, searching for background information, and facilitate knowledge sharing.

3.2.1.4 Decision Support Application

This application is used to facilitate information gathered, generate quick data queries (assessment report), facilitate information sharing (convert data into usable information), and provide consultation information.

3.2.1.5 Warning Application

This application is used to identify parties for notification and facilitate the generation and distribution of warning information.

Emergency response service is not just time-dependent, but also information dependent. There are five main databases within the MERS application component:

- **Personal Database:** contains information about mobile phone number, personal name, date of birth, address and other basic personal data
- **Organisation Database:** contains organisation /expert name, organisation/expert type, region activities, and services provided. It is with a G2G platform

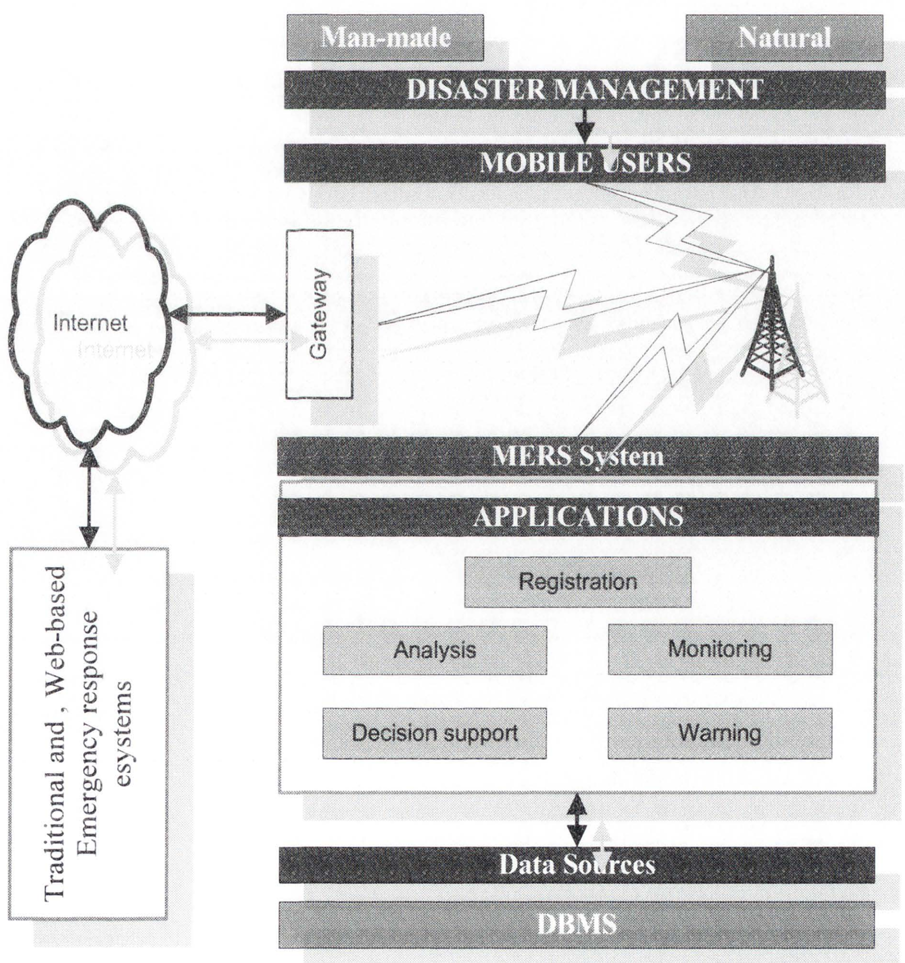


Figure 3.4: An MERS technical framework

- **Disaster Database:** contains all background information about disasters reported to this system
- **Emergency Request Database:** contains all information collected from responses for an emergency situation caused by a disaster, such as mobile phone number, and text message
- **Emergency Response Database:** contains all information related to actions taken against emergency situation, such as warning message (text), and experts involve in a disaster.

The sequential diagram of MERS process is shown in Figure 3.5. A MERS is a dynamic process exhibiting changes through time. In general, there are five steps that a future MERS process would include: receive emergency text message, access relevant information, analyse data, facilitate decision making, and generate warning messages.

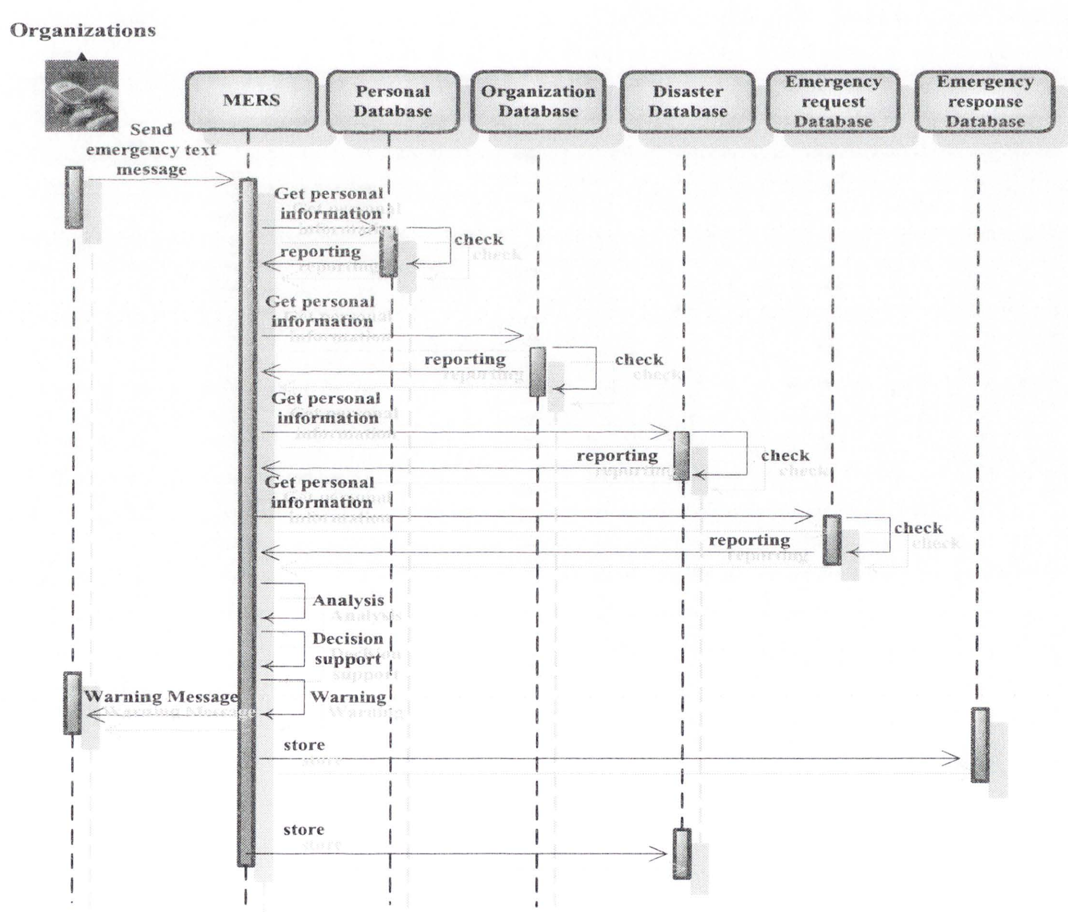


Figure 3.5: A sequential diagram of the MERS process

3.2.2 System Boundary

Many applications have shown that ICT is critical to improve response to disasters (Leysia & Sophia 2007). The Internet is emerging as a potential source of information distribution about a particular disaster. Emergency responders now have the ability to access this enormous data via websites (Robinson & Donald 2005). For example, Sahana (Careem et al. 2007) is a web-based application developed in response to disasters. Another (traditional) emergency response system is through public telephone networks. Many countries have a single number (9-1-1 in USA, 0-0-0 in Australia and 1-1-2 in Europe) that allows a caller to communicate with local emergency services. For the purposes of system development, the MERS system needs to be integrated with web-based emergency systems and traditional systems.

3.3 Cases in an MERS

The purpose of this section is to introduce two of the most important applications for MERS system. These applications are namely, information extraction and aggregation, and ontology-supported CBR for an MERS.

3.3.1 Information Extraction and Aggregation Application

Knowledge, for easy retrieval and processing by computers, should be represented in a formal, structured manner for processing and for managing it efficiently and effectively. Unfortunately, knowledge presented in mobile text messages, especially in an emergency situation, has an informal, unstructured form. In order to provide advanced knowledge, efficient ways are needed to access extract knowledge from unstructured text (Wang et al. 2008). An initial text mining processing is used to automatically extract information from unstructured mobile text messages through a detailed analysis of their content, often to satisfy particular information needs, such as providing a list of facts related to some disaster.

3.3.2 Ontology-supported CBR for MERS

CBR (Morbach, Wiesner & Marquardt 2009) is the process of solving new problems by retrieving the most relevant past problems from an existing knowledge base and adapting them to fit the new situations. Problems are referred to as cases and the previously experienced ones are stored in the case base or memory. A CBR-Ontology application is used for a decision support system (DSS).

3.4 System Evaluation

The system should be evaluated and analysed in terms of two major performance measures: effectiveness and efficiency (Turban, Aronson & Liang 2005). Effectiveness is the degree to which goals are achieved. It is therefore concerned with the outputs of a system. Efficiency is a measure of the use of inputs to achieve outputs. In other words, effectiveness is doing the right thing and efficiency is doing the thing right.

According to (Trochim 2006), the generic goal of most evaluations is to provide useful feedback to a variety of audiences including sponsors, donors, client-groups, administrators, staff, and other relevant constituencies. The most important basic distinction in evaluation types is that between formative and summative evaluation. Formative evaluations improve the object being evaluated by examining the delivery of the program or technology, the quality of its implementation, and the assessment of the organisational context, personnel, procedure, and input. In contrast, summative evaluations examine the effects or outcomes of some object—they summarise it by describing what happens subsequent to delivery of the program or technology; assessing whether the object can be said to have caused the outcome; determining the overall impact of the causal factor beyond only the immediate target outcomes and estimating the relative costs associated with the object.

3.5 Chapter Review

This chapter presented an MERS framework that has five main components (register, monitoring, analysis, decision support, and warning) aiming to provide a new function and service to m-Government. The proposed MERS framework would also offer a new opportunity for interaction among government, citizens, responders and other non-government agencies in emergency situations.

This chapter also briefly introduced three of the most important applications for an MERS. The goals of these applications are to extract and aggregate SMS text messages received from mobile phone users in an emergency situation, develop a CBR-Ontology approach for a decision support system that can improve the efficiency of decision makers in an emergency situation, and finally, investigate knowledge management through Interest entities in emergency situations. These applications will be explained in detail in the following chapters.

Chapter 4: Domain Knowledge Representation and Processing for MERS

Ontology is an explicit specification of a conceptualisation

Gruber, 1993

This chapter presents a knowledge-based (KB) system in order to support the MERS design. The system contains two kinds of domain knowledge, including ontology and CB domain. Ontology has been used to improve the performance of an IE system, enabling the definition of case structure and of the query vocabulary. A case is used to retain knowledge gained from previous experience. . The organisation of this chapter is explained in Table 4.1.

Table 4.1: Organisation of Chapter 4

4.1	Introduction
4.2	Ontology-Based Representation for Unstructured SMS Texts 4.2.1 Basics of Ontology 4.2.2 Ontology Requirements
4.3	OBIE Ontology
4.4	Case Representation and Indexing 4.4.1 Specification of an emergency situation 4.4.2 Solutions description 4.4.3 Outcome description
4.5	Emergency Response Ontology
4.6	Chapter Review

4.1 Introduction

This chapter deals with domain knowledge. The MERS concerns two kinds of domain knowledge: domain ontology and case base. The domain of ontology contains a hierarchy framework that primarily includes classes of terrorism disaster and the primary relations between these classes. The case-based domain contains a record of a previous experience or problem.

The objective of this chapter is to give an overview and explanation of the MERS domain knowledge. Section 4.1 begins with the basics and requirements of ontology. Ontology has been used to improve the performance of IE systems. Section 4.2 presents ontology for knowledge about terrorism disaster. The ontology contains a hierarchy framework for domain that primarily includes classes of terrorism disaster and primary relation between these classes. Case representation and indexing is introduced in Section 4.3. The details will include specification of the problem and the relevant attributes of the environment that describe the situations of the problem. Section 4.4 presents an emergency response ontology domain that has been established for case classification

4.2 Ontology-Based Representation for Unstructured SMS Texts

4.2.1 Basics of Ontology

Ontology has been used in many IE systems (Tran Quoc & Kameyama 2007). Here, the general idea is to use ontology to guide the IE process and to present the results. The development of ontologies is a complex task based on knowledge management and domain experts (Malizia et al. 2010). This section explains the method used to extract information from an SMS text message, utilising the knowledge in ontology. The system uses a domain ontology built with the Protégé tool. Some existing domain ontologies such as in (Herrera et al. 2009; Recio-Garía & Díaz-Agudo 2007) were reviewed, which proved useful for the purposes of this thesis.

Ontology consists of classes, properties, individuals (also known as instances and objects), property values of individuals and constraints. In OWL ontology, the word 'concept' is sometimes used in place of class. Classes are a concrete representation of concepts. In the IE domain, examples of classes are DISASTER-LOCATION, DISASTER-EVENT, PHYSICAL-TARGET, and WEAPON-USED. In OWL ontology, classes describe concepts about class membership and property values of individuals. A class can have subclasses that represent concepts that are more specific than the superclass. The class of DISASTER-LOCATION can be divided into TEMPORAL-LOCATION, and SPATIAL-LOCATION. A class is differentiated from other classes according to their properties (i.e. different classes have different sets of properties). In the Ontology-Based Information Extraction (OBIE) system, IE techniques are normally used to extract individual classes and property values for individuals. For example, the property set of SPATIAL-LOCATION class might include Street name, State, and Zip code.

An OBIE system is defined as a set of extractors aims to identify individuals of a given class or property values for individuals. Formally, this can be presented as follows.

4.2.1.1 Definition of Ontology

An ontology O is a quintuple, $O = (O_C, O_P, O_I, O_V, O_A)$ where O_C, O_P, O_I, O_V, and O_A are used to refer to sets of classes, properties, individuals, property values and other axioms (such as constraints) respectively (Wimalasuriya & Dou 2009).

4.2.1.2 Definition Ontology-Based Information Extraction System (OBIE)

The OBIE for an ontology O is defined as a set of n extractors as follows:
$I(O) = \{E(O, X_i)\}$, where $\forall i\ (1 \leq i \leq n)$, $X_i \in O_C$ or $Xi \in O_P$ or $X_i \in O_I$, or $X_i \in O_V$, or $X_i \in O_A$ for a given SMS messages S.

4.2.2 Ontology Requirements

In order to support IE analysis tasks, a number of ontology requirements are needed. The following requirements are applied to an OBIE system:

- **Domain interest model:** The ontology must be designed according to the domain interest of the SMS text. Entities that are to be detected in an OBIE system need to be contained in the ontology in form of classes.

- **SMS text classes:** The ontology needs individuals that represent object in the domain of discourse in order to be able to connect individuals with their real world equivalents. That is, if a physical target entity is known to exit, it must have an equivalent in the ontology (namely, an instance *UTS* in the Educational_Building subclass).
- **Lexical information:** The ontology needs lexical information about disaster events to enable the detection of named entities in SMS text. Lexical information are stored in databases that includes the full names of entities, as well as their synonyms, common variants and misspellings.
- **Class properties:** In ontology, properties are binary relations on classes (i.e. properties link two classes together). *Object properties,*[1] *Datatype* properties,[2] and *Annotation properties*[3] are very basic types of class relationships. An example of object properties is the one between individual UTS and individual Jones St. UTS *has-street-name* Jones St. An example of Datatype properties is the one between the individual Jones to the data literal 'St', which has a type of an xsd:string. An example of Annotation properties is the one between the sub-class STATE to the data literal (char) 'NSW'.

Figure 4.1 shows the primary classes of OBIE ontology. The ontology is represented in OWL-DL and was created using the using Protégé tool.[4] Here, object properties that specify relations between class instances are used. For example, the Disaster event class has a *has-status* object property that is defined as having the domain 'Disaster event' and the range 'Disaster status' linking a Disaster event instance to the Disaster status instance.

---

[1] Object properties link an individual to another

[2] Datatype properties describe relationships between an individual and data values

[3] Annotation properties can be used to add information (metadata—data about data) to classes, individuals and object/datatype properties.

[4] Protégé ontology editor, http://protege.stanford.edu/

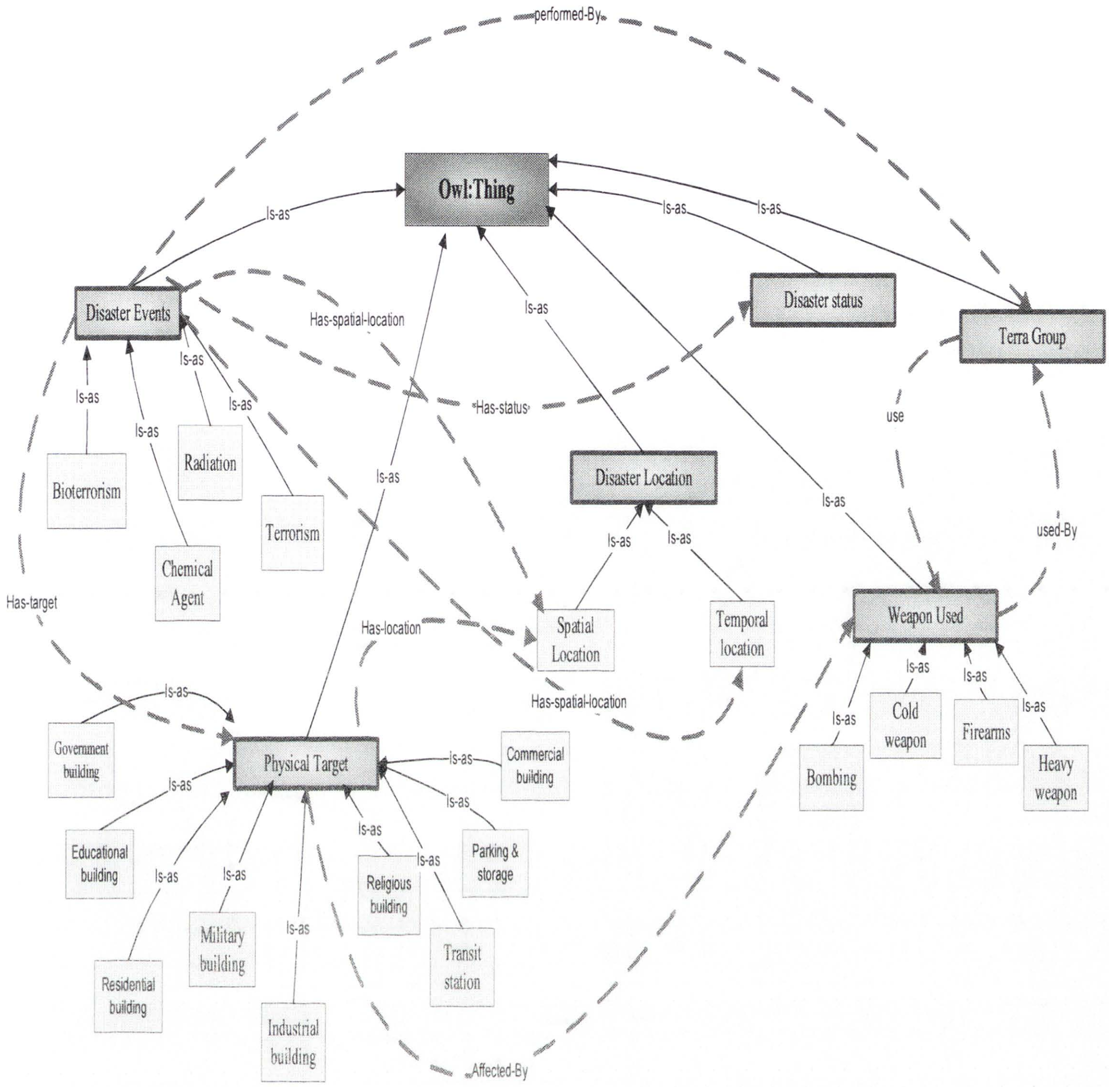


Figure 4.1: Relations between classes and instances

4.3 OBIE Ontology

In this chapter, the ontology for the SMS text messages domain has been developed for experimental purposes of text classification. In the domain ontology, a SMS text message domain ontology is constructed with seven main entities, including: physical target; disaster location; human target; weapon used; stage of execution and disaster event. All the entities are dividing into categories and sub-categories. Table 4.2 shows the main concepts together with a brief definition and Figure 4.2 shows a part of the ontology structure.

Table 4.2: Ontological concept definitions and example

Concept	Definition	Example of Instances
Disaster Event	Based on disaster styles, a disaster event is classified into five types: Bioterrorism, Chemical Agent, Radiation and Terrorism	Chemical attack
Disaster Location	Represents any location mentioned in an SMS message that is connected to the disaster event	Sydney
Stage Of execution	Disaster status	in progress, accomplished, attempting
Number of Deaths	Number of people killed	34
Number of Wounded	Number of people injured	235
Instrument Used	The common weapons used in a disaster event, such as heavy weapon, grenade attack, fire arms attack and cold weapon attack	Machine Gun
Physical Target	The building type mentioned in an SMS text. It is a Military terrorist target or a Civilian terrorist target.	UTS University
Date & Time	The date and the time of a disaster event	12:00AM
Magnitude	A measure of the disaster event degree	Low, Medium, High
Area Affected	This indicator covers areas affected by the disaster event	$200m^2$

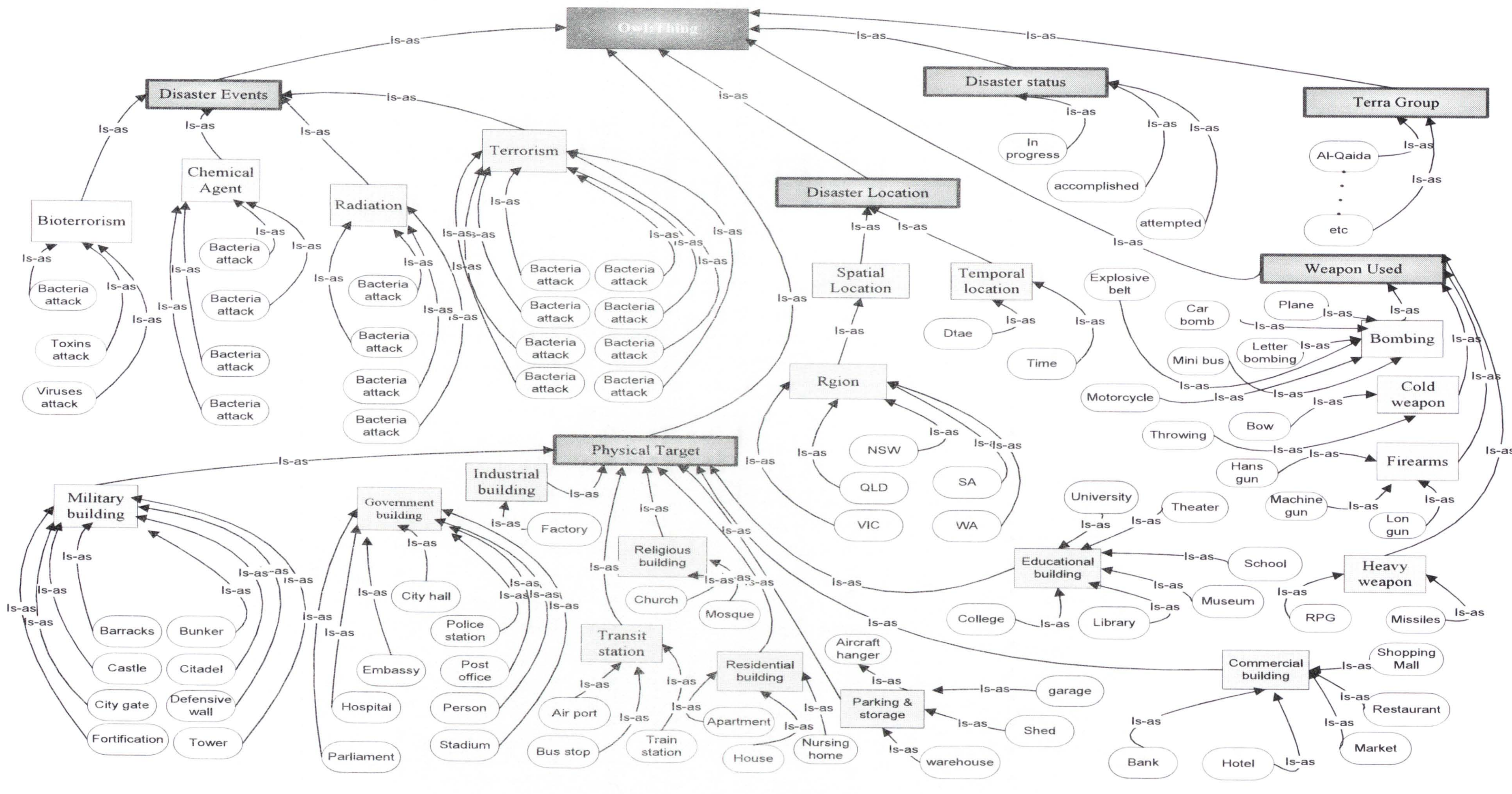


Figure 4.2: OBIE ontology

An example is used to support the understandability of the extraction method used here and its implementation. The domain of disaster location has been chosen because the domain is widely known and its characteristics are suitable for extraction. Figure 4.3 shows a possible conceptualisation of the domain containing only relevant aspects of a particular domain. In this sense, ontology can be regarded as the task specification where the properties of concepts represent the properties for which the extraction method has to determine appropriate values from input data.

Figure 4.3: Graphical representation of disaster spatial location

4.4 Case Representation and Indexing

The most challenging task in the CBR process is case representation. A case representation must be expressive enough for users to describe a case accurately (Shiu & Pal 2004). After an extensive literature review, the most common perceptive attributes that will affect the restoration of an emergency situation are defined. The cases here are represented by several levels of detail, outlined below.

4.4.1 Specification of an emergency situation

This involves specification of the problem and the relevant attributes of the environment that describe the circumstances of the problem. Table 4.3 describes the most important features from extensive and complicated cases point of view, to facilitate retrieving suitable cases. These features are viewed as the attributes of each case in the database.

Table 4.3: Case attributes of an emergency response system

Attributes	Definition	Description	Data type
Case Name	Restored case name	N/A	Text
Disaster Event	Based on disaster styles, disaster event is classified into five types	Bioterrorism Chemical Agent Radiation Terrorism	Choice
Disaster Location	Represents any location mentioned in a SMS message that connected to the disaster event	State, city	Numerical/ String
Stage of execution	Disaster status	In progress Accomplished attempting	Choice
Number of Dead	Number of people killed	N/A	Numerical
Number of Wounded	Number of people injured	N/A	Numerical
Instrument Used	The common weapons used in a disaster event	Heavy weapon Grenade attack Fire arms attack Cold weapon attack	Choice

Physical Target	The building type mentioned in a SMS text. It is a physical target such as an educational building.	Military terrorist target Civilian terrorist target	Choice
Date & Time	The date and the time of a disaster event	AM or PM	Choice
Magnitude	A measure of disaster event degree	Low, Medium, High	Choice
Area Affected	This indicator covers areas affected by disaster event	N/A	Numerical
Temperature	Quantitatively expresses the common notions of hot and cold	N/A	Numerical
Fire	This indicator covers areas affected by fire in disaster event	YES or NO	Choice
Evacuation	This indicator shows the mass movement of persons from a dangerous place due to a disaster event	YES or NO	Choice
Persons with disability	This indicator illustrate the aspect of evacuating a person with a disability	YES or NO	Choice
Explosive Attack	Explosive devices are use in the disaster situation	YES or NO	Choice
Hijacking	Hijacking condition	YES or NO	Choice
Biological Attack	Biological weapons and the use of bioterror	YES or NO	Choice
Chemical Attack	Chemical incident condition	YES or NO	Choice

'Disaster Event', 'Disaster Location', 'Stage Of execution', 'Instrument Used', 'Physical Target', 'Time', 'Magnitude', 'Fire', 'Evacuation', 'Persons With Disability', 'Explosive Attack', 'Hijacking', 'Biological Attack', 'Chemical Attack' are the fundamental architecture settings for defining the disaster event. These fourteen attributes are represented by the choice data type in the database. 'Numbers of Dead', 'Number of Wounded', 'Area Affected', 'Temperature' are four attributes that can be represented by numerical value data. MySQL (structured query language)-style statements were used to represent the database as seen in the example below.

Example of SQL command for creating tables

```
CREATE TABLE disaster_case {
        Case Name varchar(15), NOT NULL PRIMARY KEY
        Disaster Event ENUM('Bioterrorism', 'Chemical Agent',
                'Radiation Emergency ', 'Terrorism'),
        Instrument Used ENUM('Heavy weapon', 'Grenade attack',
                'Fire arms attack', 'cold weapon attack'),
        Physical Target ENUM('Military', 'Civilian'),
        State ENUM('ACT', 'NSW', 'NT','QLD','SA','VIC','WA'),
        City varchar(15),
        Stage Of execution
        ENUM('Inprogress', 'Accomplished', 'Attempting'),
        Number of Dead int,
        Number of Wounded int,
        Time ENUM('AM', 'PM'),,
        Magnitude ENUM('Low', 'Medium', 'High'),
        Area Affected  int,
        Temperature int,
        Fire ENUM('Y', 'N'),
        Evacuation varchar(4),
        PersonsWithDisability ENUM('Y', 'N'),
        ExplosiveAttack ENUM('Y', 'N'),
        Hijacking ENUM('Y', 'N'),
        Biological Attack ENUM('Y', 'N'),
        ChemicalAttack ENUM('Y', 'N')
};
```

After creating the table, the MySQL insert process can be carried out in several ways such as web-based graphic interface, by using a PHP script, and s scripts written in other languages: Perl, Python, and JAVA. Cases in the relational database tables can be retrieved later using SELECT-FROM-WHERE MySQL statements.

4.4.2 Solutions description

This describes the stated or derived solutions to the problem. It comprises tasks and constraints subclasses. The emergency response solution here consists of four major phases: response preparation, emergency response, and emergency rescue (Xiang et al.

2008). Response preparation is responsible for providing resource support, such as emergency team support, emergency logistics support and emergency technical support. Emergency response is responsible for launching expert group and establishing reliable communication and emergency rescue is responsible for providing an evacuation plan and medical aid and alerting emergency notifications.

4.4.3 Outcome description

This describes the results when the solution parts is carried out in pervious an emergency situation. The outcome process includes benefits, status and risks. Benefits include feedback from the real world and interpretations of the feedback after carrying out the solutions. Status includes positive or negative consequences after carrying out the solutions. Risks include problem interpretations of the feedback after carrying out the solutions. Table 4.4 illustrates an example of a case structure.

Table 4.4: An example of a case structure

Problem Description:
Case ID: CASE01
Case Name: UTS bomb car explosion
Disaster Location:
Street name: Jones St , **Street No:** 16/550, **Post Code:** 2007
City: Sydney, **State:** NSW
Stage Of Execution: Accomplished
Human Target:
Number of Dead: 20
Number of Wounded: 15
Instrument Used: Car bomb
Physical Target: Educational Building
Date & Time: 12/10/2009 at 02:08PM
Magnitude: High
Area Affected:200m2,
Temperature:26
Fire: YES
Evacuation: YES
Persons With Disability: NO
Explosive Attack: NO
Hijacking: NO
Biological Attack: NO
Chemical Attack: NO

Solution: **Step 0:** Activate an appropriate alarm **Step 1:** All fires, regardless of how small must be reported. **Step 2:** All spills that result in a release to the environment must be reported. **Step 3:** Any suspicious package or any bomb threat must be reported.
Constraints: None
Outcomes: **Benefits:** Suitable for complex problem. Suitable for sequential problem solving. **Status:** Positive consequences **Risks:** None

Case indexing refers to the features that stored cases should have for retrieval and comparison tasks. Indexes should be carefully selected to enable retrieval of the right case at the right time (Shiu & Pal 2004). Cases are generally indexed through attributes associated with problem description Indexes should be simple and reflect the important aspects of the case.

In a CBR method, a case indexing is defined as a set of attributes aims to identify features of the problem. Formally, this can be presented as follows:

Definition Case Indexing 5.1. A case indexing can be described as a set of feature attribute denoted by $F=\{f_1,f_2, \ldots, f_n\}$, n is the number of attributes. Then the global feature weight of each feature attribute can be described by $WF=\{w_1f_1,w_2,f_2,\ldots, w_nf_n\}$, w_i is the weight of feature attribute f_i, , $i=1,2\ldots n$.

4.5 Emergency Response Ontology

According to (Recio-Garía & Díaz-Agudo 2007), ontology would support a CBR system in different ways. As the vocabulary, ontology enables the definition of case structure. As the terminology, ontology enables the definition of the query vocabulary. Ontology facilitates similarity assessment by making a connection between the query terminology and the case base terminology. In this chapter, the ontology for the emergency response domain has been developed for experimental purposes of case classification. Ontology stores the information about the case attributes. A snapshot example of emergency response ontology is shown in Figure 4.4.

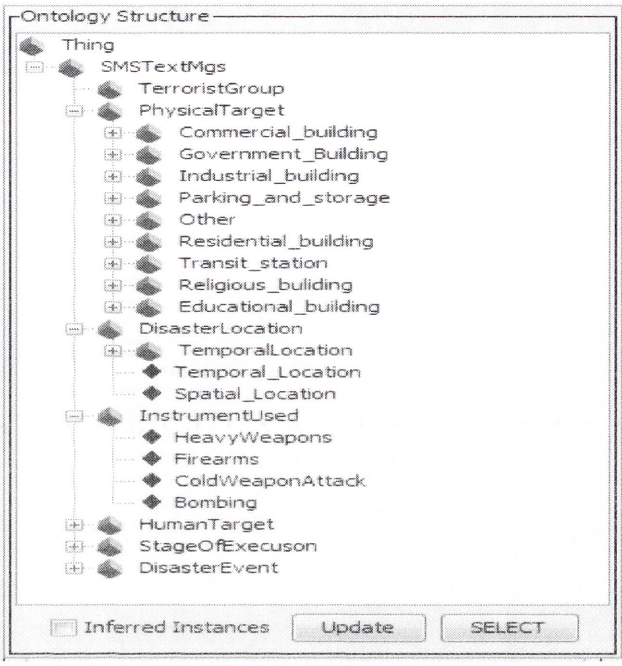


Figure 4.4: Ontology structure of SMS text messages

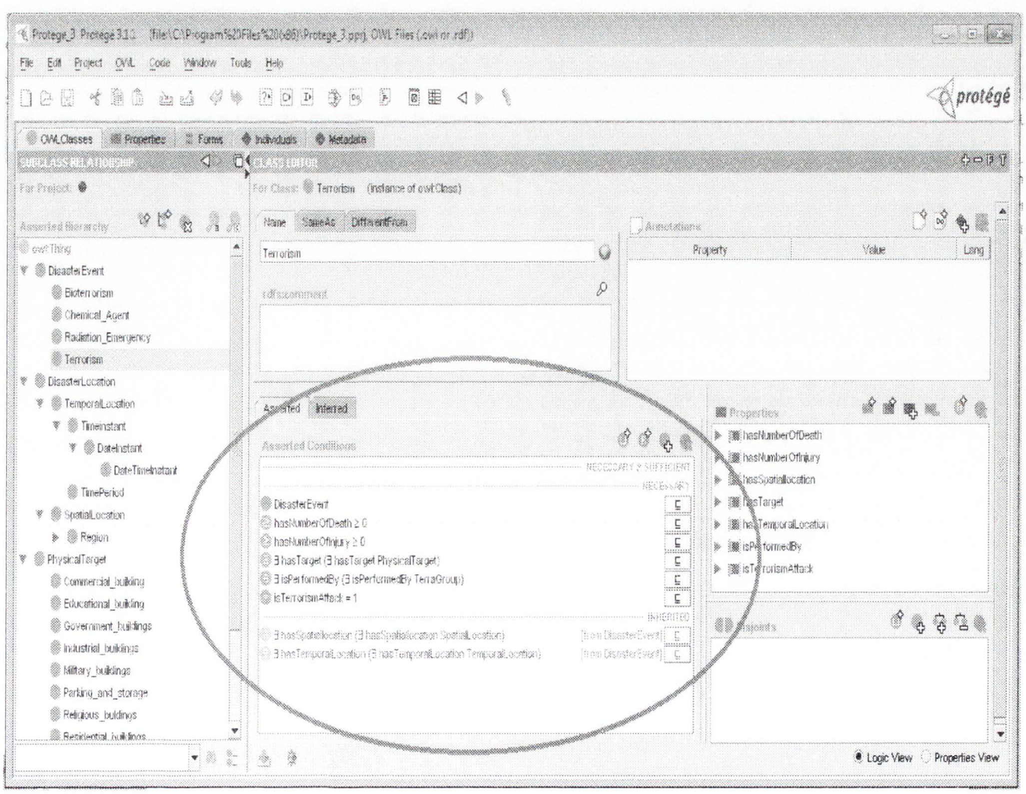


Figure 4.5: The taxonomic hierarchy associated with disaster location

In the domain ontology, a case attributes domain ontology is constructed with four main classes using Protégé tool: physical target; disaster location; instrument used and disaster event. All the classes are divided into sub-classes. Each class is associated with a number of properties and restrictions that defined the necessary and sufficient conditions for membership of the class. For example, the Disaster Event class is associated with a number of properties that provide further information about the disaster situation. In the context of emergency response ontology, these properties capture information on various factors such as the spatial and temporal location of the attack and weapons used. Figure 4.5 presents a part of the ontology taxonomy. The taxonomy represents relevant disaster location domain as classes and their relationships as 'is-a 'and 'has-a' links, which allows the inheritance of features from parent classes to child classes.

4.6 Chapter Review

This chapter presented the domain knowledge system to support the MERS system. Domain knowledge is the fundamental part of the MERS system. The KB system presented here consists of two main parts: ontology representation and CB domain. In this chapter, the ontology for the SMS text messages domain has been developed for the purpose of experimental text classification. An ontology-based approach (presented in theory in Chapter 5) was used to improve the performance of IE systems. Next, case representation and indexing were explained, which will develop a formal semantic representation of the objects for case representation in the ontology for CBR approach (presented in theory in Chapter 6).

Chapter 5: OBIE and Aggregation for MERS

Everything should be made as simple as possible, but not simpler.

Albert Einstein

This chapter describes an algorithm within an MERS to automatically extract information from SMS messages. The algorithm is developed based on an ontology concept and a maximum entropy statistical model(Amailef, Lu & MA 2009). Ontology has been used to improve the performance of IE systems. A maximum entropy statistical model with various predefined features offers a clean way to estimate the probability of certain tokens occurring with a certain SMS text. The algorithm has four main functions: to collect unstructured information from SMS emergency text messages; to conduct IE and aggregation including lexical analysis, name entity recognition, merging structure, and normalisation and duplication; to calculate the similarity of SMS text messages and to generate query and results presentation. The organisation of this chapter is explained in Table 5.1.

Table 5.1: Organisation of Chapter 5

5.1	Introduction
5.2	Tokenisation Models
5.3	NER
5.4	ME Model
5.5	Feature Set Used by ME Model Classifier 5.5.1 Slipping window 5.5.2 Previous token tags 5.5.3 Pattern feature
5.6	System Architecture for SMS Text Extraction and Aggregation 5.6.1 Pre-Processing (Lookup Resources) 5.6.2 Information Processing 5.6.3 Similarity Measures 5.6.4 Presentation of Results
5.7	An Illustrated Example
5.8	Chapter Review

5.1 Introduction

To speed up the progress of an MERS, it is important to develop a scalable learning method to efficiently process large amounts of SMS text messages and extract and aggregate the results into a structured format that is easy for retrieval and analysis by decision makers in a disaster situation. The objective here is to find facts in SMS text messages and code them in a relational database. These facts could be disaster events, disaster locations, weapon used, disaster status, number of injured people or number of deaths.

This chapter outlines one of the most important tasks within MERS applications, IE and aggregation. It also focuses on a statistical technique for information detection and classification, ontology, which has been used to improve the performance of IE systems. Ontology for knowledge about terrorism disaster situation is provided. The ontology contains a hierarchy framework for a domain that primarily includes classes of terrorism disasters and primary relation between these classes.

5.2 Tokenisation Models

The purpose of IE is to find information out of unstructured data. The unstructured data sources that this thesis is mainly concerned with are SMS text messages. The messages are decomposed into a sequence of tokens. The sequence of tokens is denoted as $T = \{t_1, t_2 \dots t_n\}$, where n is the number of token, and each token $\boldsymbol{t_i}$; $i=1,2,\dots, n$, has to be classified into one of a set of $\mathcal{L}$ labels, where $\boldsymbol{\mathcal{L}} = \{\boldsymbol{\ell_1}, \boldsymbol{\ell_2} \dots \boldsymbol{\ell_m}\}$, and m is number of labels.

The set of labels $\mathcal{L}$ comprise the set of entity types E and a special label 'NONE' for none-labelled tokens (i.e. tokens that do not belong to any entity type). Table 5.2 shows an example sequence of eleven words. For example, for segmenting terrorism disaster situation into its constitute field, use:

$\mathcal{L} = \{\ell_1, \ell_2, \ell_3, \ell_4, \ell_5, \ell_6\}$, where

$\ell_1 = \{Street\ no\}$

$\ell_2 = \{Street\}$

$\ell_3 = \{building\ no\}$

$\ell_4 = \{buolding\ name\}$

$\ell_5 = \{weapon\ used\}$

$\ell_6 = \{NONE\}$

Table 5.2: Tokenisation of SMS text into a sequence of tokens

i	1	2	3	4	5	6	7	8	9	10	11
T	a	car	bomb	attack	near	UTS	building	10	227	king George	St
$\mathcal{L}$	ℓ_6	ℓ_5	ℓ_5	ℓ_5	ℓ_6	ℓ_4	ℓ_3	ℓ_3	ℓ_1	ℓ_2	ℓ_2

5.3 NER

Named entity recognition (NER) classifies every word in a document into some predefined categories (Saha et al. 2010). (Yang, Lin & Li 2008) defined NER as the identification of text terms referring to items of interest. NER is important for semantically oriented retrieval tasks, such as question answering (Kim & Kim 2008), biomedical retrieval (Li, Zhou & Huang 2009), trend detection and event tracking (Valentin et al. 2008). Much research has been carried out on NER, using both knowledge engineering and machine learning approaches (Hai Leong & Hwee Tou 2003; Montoyo et al. 2005).

Several approaches have proved to be successful in employing NER development. The Hidden Markov Model (HMM) (Shaojun 2004), Maximum Entropy (ME) (Saha, Sarkar & Mitra 2009; Sun et al. 2007), Conditional Random Field (CRF) (Sun et al. 2007), and Support Vector Machine (SVM) (Takeuchi & Collier 2005) are the most commonly used techniques. In this chapter, a ME statistical model is used for name-entity recognition. The ME is a flexible statistical model that assigns an outcome for each token (word) based on its history and features. For example, in an SMS text including a title element such as 'St' after a proper name, a proper name is the name of a street. In the sentence: 'Car bomb attack in Oxford St', the term 'Oxford' is recognised as the name of a street because it is a proper name preceded by a term that belongs to contextual information ('St'). In the above example, it can directly be concluded that the term 'Oxford' is a proper street name because of its features (spelling with an upper case in the beginning and followed by the element 'St'.

5.4 ME Model

The ME model has been applied in many areas of science and technology such as natural language processing, text classification, and machine learning (Javed, Emine & Virgiliu 2005). It produces a probability for each category of a nominal candidate conditioned on the context in which the candidate occurs. It is a flexible statistical model that assigns an outcome for each token based on its history and features. The conditional probability can be computed (see Equations 5.1 to 5.4) as:

$$p(o\backslash h) = \frac{1}{Z(h)} \prod_{j=1}^{k} \propto^{f_j(o,h)} \quad (5.1)$$

$$t = argmax\, p_i\,(o\backslash h) \quad (5.2)$$

$$Z(h) = \sum_h \prod_{j=1}^{k} \propto_j^{f_j(o.h)} \quad (5.3)$$

where *o* refers to the outcomes and *h* is the history or the context, history can be viewed as all the information derivable from the training corpus relative to the current token. *Z(h)* is a normalisation function and is equal to 1 for all *h*. $f_j(j=1,2,\ldots k)$ are known as features that are helpful in making predictions about the outcome. Parameter α_j is weight of feature f_j, where $f_j\ (o,h)$ (Kim & Kim 2008). For instance, for the problem of SMS emergency text categorisation, feature function can be defined as follows:

$$f(o,h) = \begin{cases} 1, \ iff\ o = disaster - locationand \\ \quad and\ current\_word(h) \in Dictionary \\ \\ 0, \ otherwise \end{cases} \quad (5.4)$$

Another example can be used to explain the ME model. To model the probability of a named entity being a weapon use or not when it appears in an SMS text, consider the set of the word to be classified as:

$$\Omega = \{UTS, 15\ Broadway, NSW, Sarin\ gas\} \tag{5.5}$$

The goal is to compute the combined probability distribution *P* defined over:

$$S = X \times Y \tag{5.6}$$

Where

$X = \{UTS, 15\ Broadway, NSW, Sarin\ gas\}$

$Y = \{Weapon\}$

$\sum_{x,y} P(x,y) = 1$ Or

$$P(UTS, Weapon) + P(15\ Broadway, Weapon) + P(NSW, Weapon) + P(Sarin\ gas, Weapon) = 1 \tag{5.7}$$

Table 5.3 shows the distributions satisfied the above constraint in Equation 5.7.

Table 5.3: An example of a distribution probability

Words	Probability
UTS	¼
15 Broadway	¼
NSW	¼
Sarin gas	¼
Total	1.00

Obviously, for a weapon used in a disaster event, the following constraint can be considered:

$$f(o,h) = \begin{cases} 1, & iff\ o = Weapon\ and \\ & and\ current\_word(h) \in Weapon \\ 0, & otherwise \end{cases} \tag{5.8}$$

In Table 5.4 look for the most uniform distribution satisfying these constraints in Equations 5.7 to 5.8.

Table 5.4: a probability that satisfies the constraints in Equations 5.7 to 5.8

words	Probability
UTS	0.0
15 Broadway	0.0
NSW	0.0
Sarin gas	1.0
Total	1.0

5.5 Feature Set Used by ME Model Classifier

In order to apply the ME model to an emergency response domain, a set of selected features are required for setting the constraints. Since the features are critical to the success of machine learning approaches (WU, Tsai & Hsu 2005), they will be discussed in more detail. An ME model makes use of features for the name-entity recognition task. These features are easy to develop and require no deep domain knowledge. Most of these features are general and they are not specific to the emergency response disaster domain. The features used in the model developed here are derived from (Malizia et al. 2010; Pinto & Martins 2004; Wu, Lee & Yang 2008) and are described below.

5.5.1 Slipping window

Typically, word windows are of size 5 and consist of the current token, two tokens to the left and two tokens to the right (e.g. $w_{-2}\ w_{-1}\ w_0\ w_1\ w_2$). This feature is useful for determining the entity class to which the current token belongs.

5.5.2 Previous token tags

These features are helpful for capturing information on the interdependency of the label sequence.

5.5.3 Pattern feature

This feature is used to determine a set of decision rules that would produce a positive example. For example, the part of SMS (or a sequence of tokens) matches a certain linguistic pattern. However, the following features are often very useful:

- **Capitulation and digit information:** Semantic or syntactic type information can provide useful information. for example, initial capital, all capital, capital in inner, initial capital then mix, only digit, real number, digit with special character, initial digit then alphabetic, digit in inner, etc.
- **Dictionary lookup features:** These features are used to decide whether or not a token phrase belongs to a certain prebuilt dictionary.
- **Prefix and suffix:** These features contribute to the composition of the word, which usually yields useful information on its semantics. All suffixes and prefixes of up to five characters in length are used as features.
- **Special character:** These are characters that have proved to be helpful for named entity recognition. For example, the presence of '\' (back slash) helps in identifying street number (e.g. 10/550 Punchbowl Rd). Some of the special characters are also useful for the boundary detection task.
- **Conjunction of features:** These are incidence features; for example, the conjunction of two or more tokens are used as features, which is the token phrase.
- **Part of Speech (POS) information:** The POS values of the current token, the previous two and the next two words have been used as features in this system.

5.6 System Architecture for SMS Text Extraction and Aggregation

Several processing steps are proposed to extract and aggregate SMS text messages received from mobile phone users in an emergency situation. First, unstructured information is pre-processed by storing it in a relational database. The IE algorithm is then applied, the results of which will be stored in another relational database. For decision makers, the structured information relating to tables and messages can be used to assist in responding to an emergency situation. The main components used in the

SMS text extraction and aggregation process and their interactions are depicted in Figure 5.1.

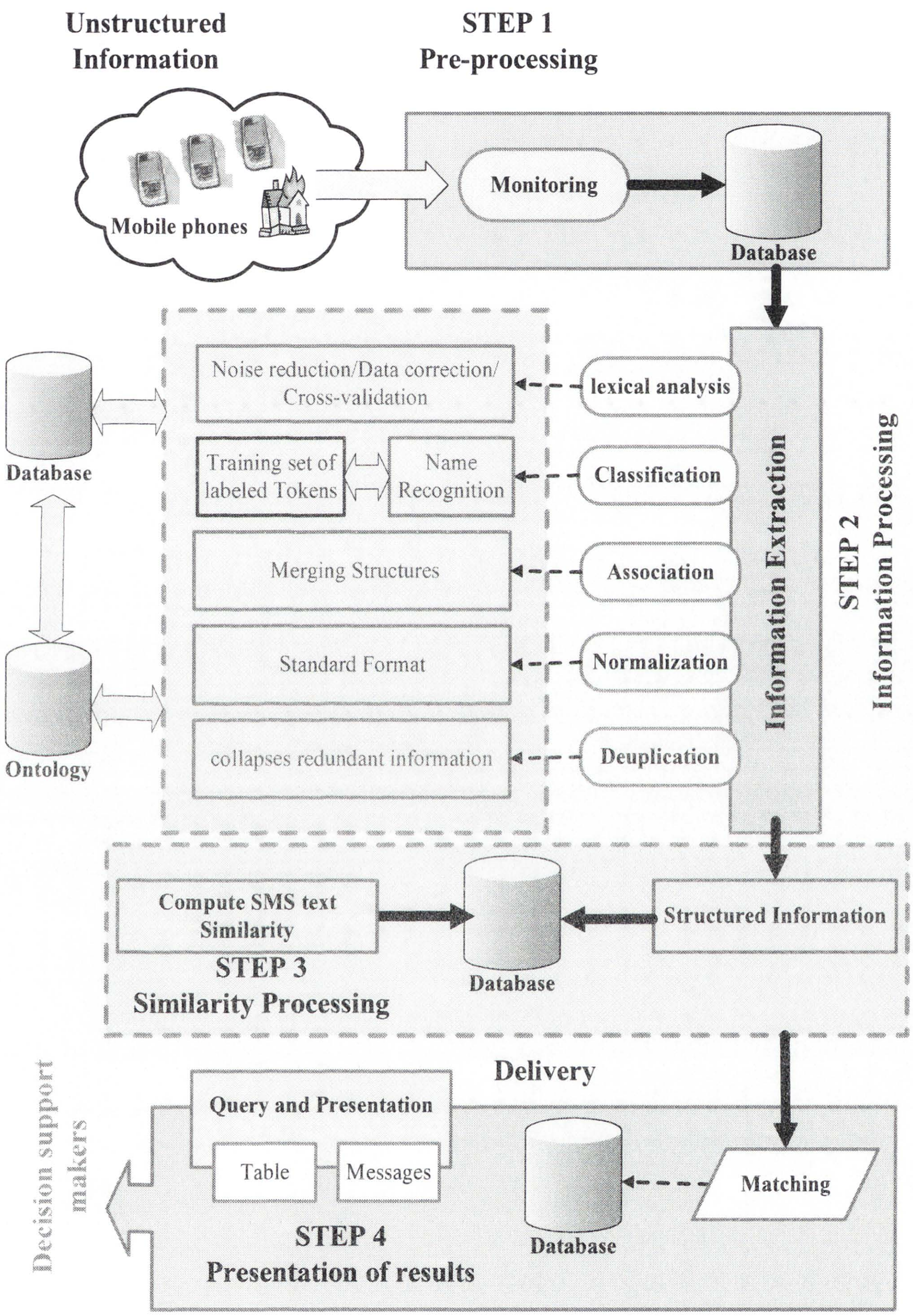


Figure 5.1: Architecture for SMS text extraction and aggregation

5.6.1 Pre-Processing (Lookup Resources)

Obviously, the first task in IE system is to collect the data. In the scenarios, the relevant data is given as SMS text messaging. The collection of SMS emergency text messages is acquired and is deposited in a relational database. The following set of attributes must be used to represent SMS messages:

- **Words:** sequences of alpha or numeric characters in the message text
- **Word bi-grams:** Sequences of *n* words in a window of five words preceding the current word.

An example of an SMS text message:

There is a car bomb attack, near UTS Uni building 10, King George St, about 10 People were killed and 20 People were injured.

5.6.2 Information Processing

Information processing is the task of finding specific pieces of information from unstructured or semi-structured documents. It can be seen as a process that aims to fill the database from unstructured SMS text messages. Information extraction involves five major subtasks:

- **Lexical analysis:** The first step in handling the SMS text is to divide the stream of characters into words or more precisely, tokens. Identifying the tokens is an essential task for the extraction of information from an SMS text. Each token represents an instance of a type. As an example, in the above example of an SMS text message, the two underline tokens ('were') represent instances of a type 'were'. Once a text has been segmented into a sequence of tokens, the next step is to convert each of the tokens into a standard form. For example,'UTS Uni' is converted to UTS University. The final step in lexical analysis is to use the stopping technique to remove information that is not useful for categorisation (so-called stop-words). For example, remove articles, propositions, pronouns and other functional words that are not related to the content. A list of predefined stop words must be developed first. The application will then identify and remove all the stop words in the SMS text based on the predefined list.

- **Name entity recognition:** Once a name entity is identified, it is classified into predefined categories of SMS text messages such as location, type of a disaster and physical target. An ME statistical model with various predefined features for the named entity recognition was used. From a mathematical point of view, the classification is a function that maps words or tokens to labels, $f : w \rightarrow L$, where w is a vector of words and L is a label. In this case, the label represents a goal that is potentially related to the words.
- **Merging structure:** This step is referred to as relation extraction for the case in which two entities are associated. For example, a disaster event may be described by multiple names. Extraction must determine which filed values refer to the same disaster event.
- **Normalisation and duplication:** Puts information into a standard format by which it can be reliably compared. For example, the status of a disaster event may be given as 'in-progress', and in another case as 'in progress'. Thus, it is necessary to avoid putting redundant information in the database.

5.6.3 Similarity Measures

After filling the database from unstructured SMS text messages, the similarity of composite SMS text messages must be calculated. The system measures the similarity based on four different types of features: disaster location, physical target, disaster event, and disaster weapon used. To do this, a query is defined to filter the resulting set of resources (SMS text). For example, MySQL[5] (structured query language) style statements were used to measure similarity in the following example:

[5] http://www.mysql.com/

Example: Java Code

```
rs = stmt.executeQuery("SELECT *, COUNT(*) from smsmgs.smstextextraction
GROUP BY Disaster_Event,Street_Name, Post_Code, State, Physical_Target,
Weapon_Used");
```

In this example, the search is carried out in the MySQL table of each retrieved resource, matching the classification with preferences (disaster event, location physical target and weapon used). This example is used to list all the data in the specified MySQL table column based on certain specified condition, followed by a numeric and linguistic aggregation operation. The simplest and most common way to aggregate numeric values is an average aggregation function. Mathematically this becomes (see Equation 5.9):

$$M(x_1, x_2, \dots, x_n) = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad (5.9)$$

where x_i is a numeric value.

To aggregate linguistic values, Xu (2004) introduced a finite and totally ordered discrete linguistic label as follows (see Definition 5.1).

Definition 5.1. Linguistic label

The linguistic label set is defined by (see Figure 5.2):

$$Let\ S' = \{S_\alpha \mid \alpha = -t, \dots, -1, 0, 1, \dots, t\} \qquad (5.10)$$

Where zero the symmetrical center and t is a positive integer. Any label in S_α must have the following characteristics:

1) $S_\alpha < S_\beta$ iff $\alpha < \beta$; and
2) The negative operator is defined as $S_{-\alpha}$

$Let\ S_\alpha, S_\beta \in S', \lambda \in [0,1]$, and their operational rules can be defined as follows:

$$S_\alpha \oplus S_\beta = S_{\alpha+\beta}, \lambda S_\alpha = S_{\lambda\alpha}$$

Where

$$S = \begin{Bmatrix} S_{-2} = very\ low, S_{-1} = low, S_0 = medium, \\ S_1 = high, S_2 = very\ high \end{Bmatrix} \tag{5.11}$$

By the above definition, $S_{-1} \oplus S_1 = S_0$, where $S_0 = medium$.

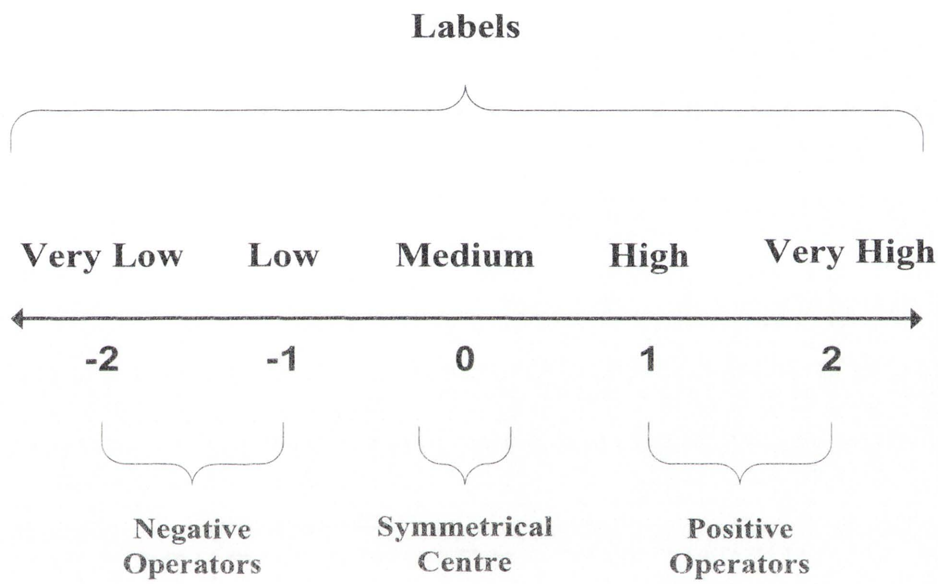


Figure 5.2: Linguistic label sets

Then, the union operation between them can be computed to give $U = \cup R_i$, where R_i is a given SMS test message such that $R_i = \{r_1^i, r_2^i, \ldots, r_m^i\}$, m is the number of words in message R_i, and r_j^i is the j^{th} word in message R_i, $i=\{1,2,\ldots,n\}$, n is the number of SMS text messages.

5.6.4 Presentation of Results

This provides decision makers and mobile users with a query related to the emergency situation. A simply query, for example, would allow the mobile phone users to receive a warning emergency text message. A query also allows decision support makers to analyse the current emergency situation. The following proposes an algorithm for SMS text extraction and aggregation.

Algorithm 1. SMS Text Classification

Input: SMS emergency text messages
Output: SMS text classification: tag $_{\alpha_i}$
Purpose: To identify all pre-defined of the structured information in the unstructured text, and, to populate a database of these entities.
1: **Input**
    $C= \{c_1, c_2 \ldots\ldots, c_n\}$ // the category set
    $S= \{s_1, s_2 \ldots\ldots, s_m\}$ // SMS messages set
2: **Collect unstructured information stage:**
4: **for** every received SMS text message **DO**
5: $database(field) \leftarrow S_i$)// store each SMS text into the relational database
6: **Endfor**
7:**Tokenisation stage:**
8: **Initialise:**
    Set currentPosition to 0
    Set delimiterSet1 to {, . ; ! ? ( ) + ' space}
    Set *delimiterSet2* to {articles, propositions, pronouns and other functional words }
9:**Procedure getToken:**
10: C=cuurentPostion; ch=charAt(C)
11: **if** ch = endofSMS then return
12 **endif**
13: **While** ch ≠endofSMS nor ch _delimiterSet1
14: token=token+ch C++; ch=chart(C)
15: **endwhile**
16: **if** token _ delimiterSet2 then
17: ts_j = token // ts, all the tokens in the SMS text, where j is the number of SMS text
18: **endif**
19: **Name Entity Recognition and merging structure stage:**
20: **Initialise:**
    $F_k= \{f_1, f_2 \ldots\ldots, f_n\}$ // is the feature set, where k type number of feature
    // $f_i(h,t) \in \{0,1\}$,t is defined as training data and h is
    // history available when predicting t
21:**Procedure Name Recognition:**
22: **Do** for every ts_j
23: Compute a maximum entropy model

$$p(o \setminus h) = \frac{1}{Z(h)} \prod_{j=1}^{k} \alpha_j^{f_j(0,h)}$$

, where α_j is weight of feature$_{f_j}$, and Z(h) is a normalisation constant

$t = \arg\max p_j(o \setminus h)$
Enddo

Algorithm 2: SMS Text Aggregation

input tag a_i // $i=1, 2, \ldots, n$
output database record
for i=1 **to** n
  if a_i exits in database
    Do case:
      Case *numeric values*
        Conduct average aggregation functions
      Case *linguistic values*
        conduct a linguistic aggregation operation
    endcase
  endif
database ($field_i$) $\leftarrow a_i$ // store each tag in the correct database field Destination
endfor

5.7 An Illustrated Example

Suppose the system receives the following SMS emergency text message:

> A chemical attack is being carried out in UTS, Building 10 level 4, 3 students were killed.

Collect unstructured information of each individual SMS emergency text message and store them in to a relational database as shown below in Table 5.5. The sender's phone number is stored if applicable, as well as the SMS test message, date and time.

Table 5.5: SMS emergency text messages database

SMSID#	Time	Date	SMS Text	Sender Phone
1	10:25am	01.01.11	A chemical attack is being carried out in UTS, Building 10 level 4, 3 students were killed	0422080991

Apply IE algorithm. The first step is to break the text into words or more precisely tokens as shown in Table 5.6. The tokenisation process consists of splitting the words and remove all unnecessary characters such as ',' and '.' from the list

Table 5.6: Words after tokenisation

Tokenised Word
A/ chemical /attack /is /being /carried /out /in /UTS /Building /10 /level /4 /3 /students /were /killed

The next step after tokenising the entire SMS text is to remove all the stop words (see Table 5.7). A stop word is a type of word that is useless for search and retrieval purpose (i.e. it has no great significance in the SMS text collection and must be eliminated in order to extract adequate key terms). Some of the most common stop words include: a, an, the, in, of, on, are, be, if, into and which.

Table 5.7: List of stopping words

Stop Word
A / is / being / out / in / were

Table 5.8 shows the outcome of the entity name recognition process based on iterate feature argument of the current word. The maximum value is eventually derived as a

result and the current word is tagged. For example, disaster location can be calculated as follows:

Given a set of answer candidate *h*= {chemical, attack, UTS, Building, 10, level, 4, 3, students, killed}. Further, *o*='Disaster Location' and a current word 'UTS' is an element of the dictionary beginning with an upper case letter. $f_1(h,o)$ and $f_2(h,o)$ are a set of binary valued features, which are helpful in making predictions about the outcome *o*. Officially, these features can be represented as follows:

$$f_1(h,o) = \begin{cases} 1, & iff\ current - token(h) \in Dictionary \\ 0, & Otherwise \end{cases}$$

$$f_2(h,o) = \begin{cases} 1, & iff\ current - token - first - letter - caps(h) \\ 0, & Otherwise \end{cases}$$

Consequently, $f_1(h,o)=1$ and $f_2(h,o)=1$. Suppose the model parameter α_1=0.5 and α_2=0.2 are weight of feature $f_1(h,o)$ and $f_2(h,o)$ *respectively*, and $Z(h)$=1 is a normalisation constant. From Equation 2, the conditional probability of word or token 'UTS' can be computed as $P(o\backslash h)= \alpha_1\times f_1(h,o)+ \alpha_2\times f_2(h,o)=0.5\times1+0.2=0.7$. The probability is given by multiplying the weights of active features (i.e. those $f(h,o)$ = 1).Then the results can be compared with the threshold value.

Table 5.8: Tokens to feature vector

Entity Name Type	Feature used	Example
DisasterLocation	Dictionary lookup features, Prefix/Suffix and digit information	UTS Building 10 Level 4
StageOfExecusion	none	none
HumanTarget	Prefix/Suffix and digit information	3 killed
WeaponUsed	none	none
PhysicalTarget	Dictionary lookup features	University
DisasterEvent	Dictionary lookup features	chemical attack

Query and information presentation. The last step is to generate a warning message based on the above extracted information. The following is an example of the warning message that will be automatically sent to mobile users:

> UTS building emergency at Building 10, level 4, if you are off campus, do not enter the campus. Wait for additional instructions.

5.8 Chapter Review

The MERS supports five major applications: registration, monitoring, analysis, decision support and warning. This chapter focused only on the monitoring application. This application is responsible for collecting complete and accurate disaster data via mobile communication devices. An extraction and aggregation algorithm was developed, which comprises the core part of the MERS. The components of the IE and aggregation process were introduced, based on ontology and a statistical model to extract information from SMS text. The proposed algorithm can extract many kinds of semantic elements of the emergency situation such as disaster location, disaster event and status of disaster.

Chapter 6: An OS-CBR System for MERS

Experience is not what happens to you; it is what you do with what happens to you.

Aldous Huxley

CBR can be defined as a model of reasoning that integrates problem solving, understanding and learning with memory processes. This chapter presents an OS-CBR approach and its implementation in the MERS to support an emergency decision maker to effectively respond to an emergency situation. The advantages of the OS-CBR approach is that it facilitates a more convenient case retrieval process in an emergency situation to depict conclusions and give recommendations based on the knowledge gained from past disasters. The OS-CBR approach includes a set of algorithms successfully implemented in four components as a sub-system of the MERS framework: data acquisition, knowledge base, knowledge presentation and reasoning. The organisation of this chapter is explained in Table 6.1.

Table 6.1: Organisation of Chapter 6

6.1	Introduction
6.2	The ontology-supported CBR approach and related algorithms
6.3	Data Acquisition and information extraction (Step 1 and Step 2)
6.4	Knowledge Base
6.5	CBR Component (Step 3) 6.5.1 Case Retrieval 6.5.2 Case Adaptation 6.5.3 Case Revise and Retain 6.5.4 Situation Assessment
6.6	Knowledge Presentation (Step 4) 6.6.1 Identification of Need for Knowledge 6.6.2 Knowledge Retrieval
6.7	Chapter Review

6.1 Introduction

A CBR method and ontology for an MERS is proposed to support and utilise decision support systems in an emergency situation (Amailef & Lu 2010). The proposed system is a predicting CBR approach. A CBR approach enables us to learn from past situations and to generate solutions to new problems based on past solutions for past problems (Wu, Lo & Hsu 2008; Yang et al. 2009). Past solutions are stored in the case base. The cases contain information about disaster events such as the disaster location or weapon used, and the system combines the efficiency of the CBR approach with ontology to depict conclusions and to make recommendations based on knowledge from the past disasters.

The CBR approach can support emergency decision makers for an ERS. The benefit of using the CBR approach is that it facilitates a more convenient retrieval process in disaster situations to depict conclusions and to give recommendations based on knowledge from past disasters. According to (Recio-Garía & Díaz-Agudo 2007), ontology would support the CBR approach in different ways. As the vocabulary, ontology allows the definition of case structure. As the terminology, ontology allows the definition of the query vocabulary. Ontology facilitates similarity assessments by making a connection between the query terminology and the case base terminology.

This chapter introduces the processes of an OS-CBR approach for an MERS system and its main components. It attempts to address the fundamental research question proposed in Chapter 1. As shown in Figure 6.1, the system consists of four main features: data acquisition, knowledge base, CBR component and knowledge presentation. This framework was adopted from (Amailef & Lu 2010).

Essentially, the basic idea expressed in this framework is to support emergency decision makers with an MERS by recalling previously successful cases for use as a guide or template. The system developed here allows users to describe cases using any concept or instance of a domain ontology, which leads to a various case base.

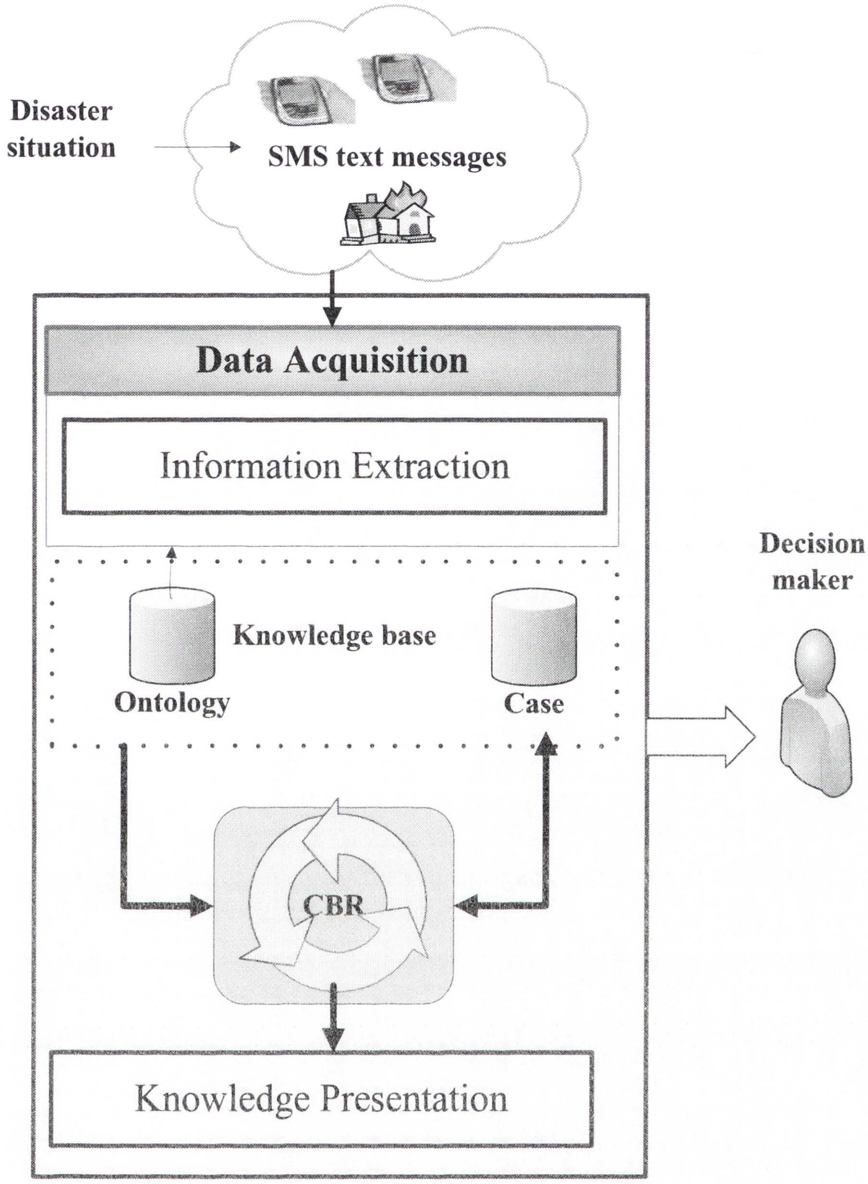


Figure 6.1: An OS-CBR system architecture

Section 6.2 describes data acquisition, Section 6.3 presents the knowledge base (KB) and Section 6.4 explains the OS-CBR approach with related algorithms. Finally, the chapter is reviewed in Section 6.5.

6.2 The ontology-supported CBR approach and related algorithms

The ontology-supported CBR (OS-CBR) approach mainly consists of:

(1) An information extraction algorithm for data acquisition,

(2) A set of ontologies,

(3) A knowledge base with related rules and cases, and

(4) A CBR component that includes an ontology case retrieval algorithm , case adaptation algorithm , case revision and retain, and

(5) Knowledge presentation.

Figure 6.2 outlines the process of the OS-CBR approach.

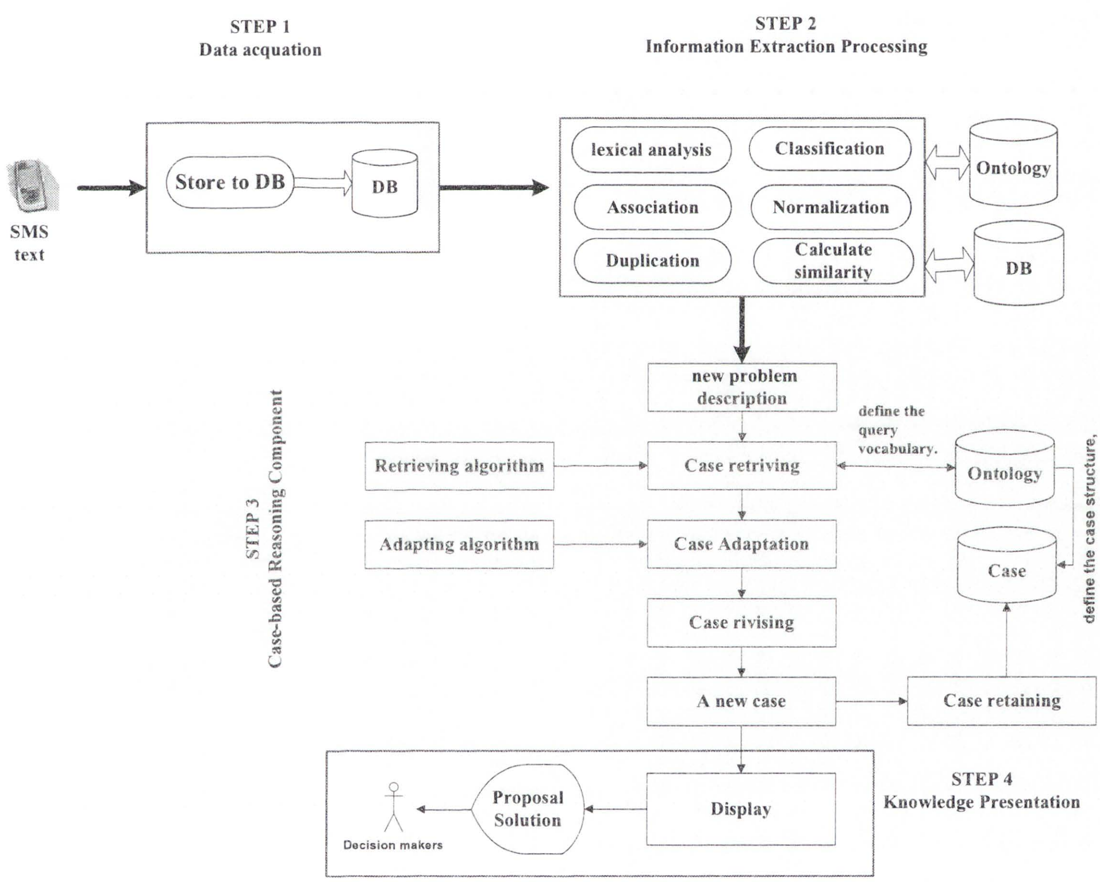


Figure 6.2: The OS-CBR approach and working process

6.3 Data Acquisition and information extraction (Step 1 and Step 2)

This component, which was described in Chapter 4, takes as input the SMS text messages received from mobile users in an emergency situation. It is used to automatically extract structured from unstructured information. This component consists of collected unstructured information from SMS emergency text messages; conduct information extraction and aggregation including lexical analysis, name entity recognition, merging structure, normalisation and duplication; and calculate the similarity of SMS text messages.

6.4 Knowledge Base

The KB stores information about a specific problem solving experience and contains cases and rules. A case is defined as a situation or problem in terms of natural language descriptions and solutions. It has three major parts: problem description, solution and outcome (Huang & Tseng 2004). A case contains a sequence of rules that represent actions taken in a particular context. For example, fuzzy rules sets that can improve the quality of the similarity results must be applied.

In a CBR method, a case is defined as a set of attributes aims to identify the instance of a problem, its solution and its outcome. Formally, this can be presented as follows.

Definition Case 6.1. A case is a three–tuple (McGinty & Wilson 2009), $C = (C_d, C_s, C_o)$ where C_d, C_s, and C_o are used to refer to sets of features that describe the problem, set of attributes that describe its solution, and the set of attributes that describe the outcome obtained by the solution C_s to the given problem C_d respectively. For a given a case base *CB*, with C_d, C_s and C_o are respectively denote the problem description, solution and outcome of a case CA_i such that $CA_i \in CB$, where $0 \leq i \leq n$, n is the number of cases in the *CB*.

A case in this MERS represents an emergency response experience and consists of three main parts (problem, solution and outcome):

- 'Problem (Disaster)' describes the problem statement when the case occurred. This class is divided into subclasses: Disaster Location; Stage of Execution; Human Target; Instrument Used; Physical Target; Disaster Event and Date and Time.

- 'Solution' describes the stated or derived solutions to the problem. It comprises tasks and constraints subclasses.
- 'Outcome' describes the resulting state after the case occurred.

6.5 CBR Component (Step 3)

The CBR is the heart of the entire MERS. This section describes the various components and features of the CBR problem solving cycle as illustrated in Figure 6.3. To successfully retrieve valuable information for MERS application, an efficient CBR process needs to be established. There is a five-stage reasoning procedure of disaster situation estimation:

1. Input the new disaster case information via the system's interface.
2. Feature identification and configuration.
3. Retrieve the cases from database based on the comparison result of case features.
4. Revise or adjust the retrieval cases according to response preparation, emergency response, and emergency rescue.
5. Retain the solution.

In Figure 6.3, a single adaptation stage replaces and combines the reuse and revise stages.

6.5.1 Case Retrieval

A case retrieval is the most crucial process in CBR design. According to a new problem provided by the user, the CBR system retrieves, from a Case Base (CB), previous cases that are similar to the new problem. For example, for a given case *C'*= {Suicide Attack, Car bomb, Sydney, 50 killed …} information on the disaster can be found through case retrieval, the process of finding those cases that are the closest to *C'*.

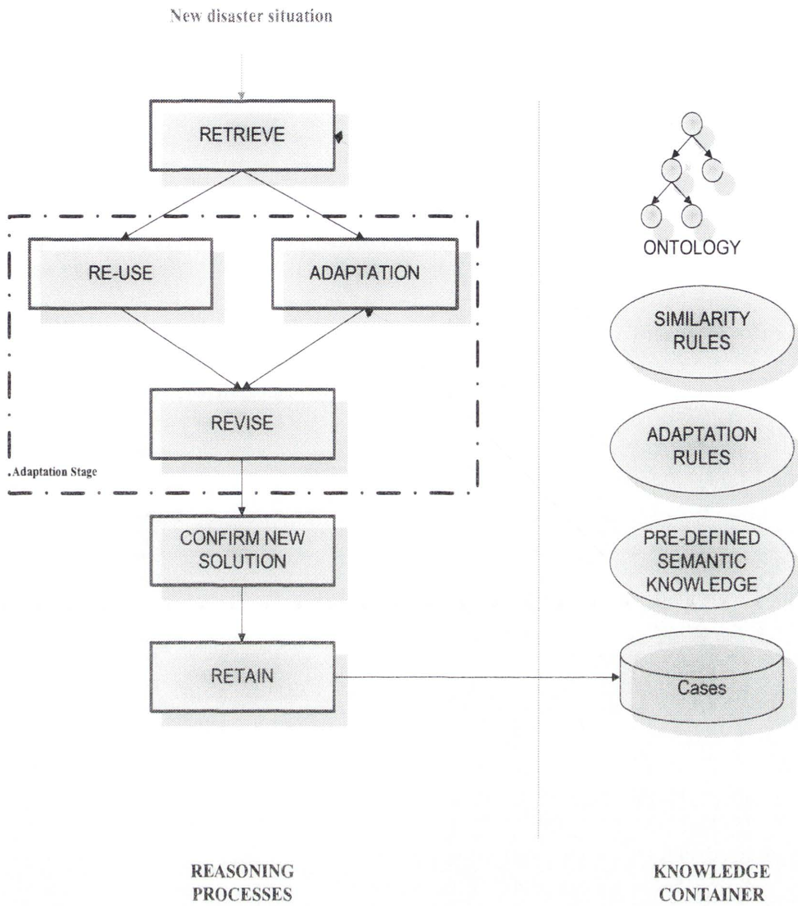


Figure 6.3: CBR architecture

Definition Compromise Assumption. In the calculation process, define two cases C_1, C_2, define vector $F^1 = (w_1f_1, w_2f_2... w_nf_n)$, $F^2 = (w_1f_1, w_2f_2, .., w_nf_n)$ to represent a features that describe the problem of C_1 and C_2 respectively, where n is the number of feature F^1 and F^2, w_n is the weight assigned to a feature f_n, define vector $Q=\{q_1,q_2,...q_m\}$ to represent target query, and S_1, S_2 are balance similarity score that is obtained from linguistic evaluation for C_1 and C_2 respectively. C_1 is more similar to the target query Q than another case C_2, if the S_1 is higher than S_2.

To retrieve the similar problem spaces from the historical cases, similarity measurement is commonly used in case retrieval. The value of similarity is between 0 (not similar) and 1 (the most similar). The total similarity value is calculated by (Virkki-Hatakka & Reniers 2009):

$$S = \frac{\sum_{\substack{i=1 \\ j=1}}^{\substack{n \\ m}} S_{ij}}{N} \tag{6.1}$$

Where S_{ij} is similarity of parameter i of new case compared to parameter j of old case. n is the number of new case parameter, and m is the number of old case parameters. N is the total number of parameters. The similarity calculation of S_{ij} depends on the data type. The possible data types are numerical, minimum and maximum numerical, text string and linguistic. For the numerical data type, the similarity value is calculated by:

$$S_{ij} = \left(1 - \sqrt{\left(\frac{C_{ij}-X_i}{max(C_i)-min(C_i)}\right)^2}\right) \cdot \frac{W_i}{10} \tag{6.2}$$

Where S_{ij} is the similarity parameter i of a new case compared to parameter j of old case. N is the number of parameters, C_{ij} *is* the value of the parameter i of the case j, X_i is the input value of the parameter i, W_i is the weight factor of the parameter i, and $max(C_i)-min(C_i)$ is the largest scope of the C_i of the case j. The interval value [a,b] is calculated by the following rules:

$$if\ data-type\ is\ 'INTERVAL'\ and\ a \leq C_{ij} \leq b\ then$$

$$S_{ij} = \frac{W_i}{10} \quad otherwise \quad S_{ij} = 0 \tag{6.3}$$

The minimum and maximal numerical value is calculated by the following rules:

$$if\ data-type\ is\ 'MIN'\ and\ X_i \leq C_{ij}\ then$$

$$S_{ij} = \frac{W_i}{10} \quad otherwise \quad S_{ij} = 0 \tag{6.4}$$

$$if\ data-type\ is\ 'MAX'\ and\ X_i \geq C_{ij}\ then$$

$$S_{ij} = \frac{W_i}{10} \quad otherwise \quad S_{ij} = 0 \tag{6.5}$$

The textual string type parameter similarity is calculated in a straightforward way, such that if the input value X_i is included in the textual string value of C_{ij}, the similarity $S_{i,j}$ = 1 (Equation 6.6).

$$if\ data-type\ is\ 'STRING'\ and\ C'(\propto_i) = C(\alpha_i)\ then$$

$$S_{ij} = \frac{W_i}{10} \quad otherwise \quad S_{ij} = 0 \tag{6.6}$$

If X_i and $C_{i,j}$ are totally differ from each other, the similarity $S_{i,j} = 0$. The linguistic value similarity (*high, medium and low*) is calculated in the following way (see Equations 6.7 and 6.8):

$$if\ X_I = C_{ij}\ then\ S_{ij} = \frac{W_i}{10} \tag{6.7}$$

$$if\ X_i \neq C_{ij}\ and\ X_i\ or\ C_{ij} = medium\ then$$

$$S_{ij} = \frac{0.5 \times W_i}{10}\quad otherwise\ S_{ij} = \frac{0.1 \times W_i}{10} \tag{6.8}$$

The threshold type parameter similarity is calculated in the following way, such that if the input value X_i is less than the value of C_{ij}, the similarity S_{ij} (see Equation 6.9).

$$if\ data - type\ is\ 'THRESHOLD'\ and\ C'(\propto_j) > X_i\ then$$

$$S_{ij} = \frac{W_i}{10}\quad otherwise\quad S_{ij} = 0 \tag{6.9}$$

In the degree similarity of membership of retrieved case to a fuzzy set (Zadeh 1965), these fuzzy linguistic evaluations can be defined as:

$$A = \begin{Bmatrix} Very\ Low(VL), Low(L), Medium(M), \\ High(H), Very\ High(VH) \end{Bmatrix} \tag{6.10}$$

$$A = \{(\mu_A(x), x) | x \in X\} \tag{6.11}$$

Where $0 \leq \mu_A(x) \leq 1$ is called the membership function. The value of $\mu_A(x)$ with a trapezoidal fuzzy number $A = (a, b, c, d; 1)$ is defined as follows:

$$\mu_A(x) = \begin{cases} \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \frac{x-d}{c-d}, & c \leq x \leq d \\ 0, & otherwise \end{cases} \tag{6.12}$$

These elements have a value ranging from 0 (not similar) to 1 (maximum similarity). This range is then transformed into the fuzzy preference function shown in Figure 6.4.

The two cases are highly similar, if the balance similarity score that is obtained from linguistic evaluation is high (see Table 6.2).

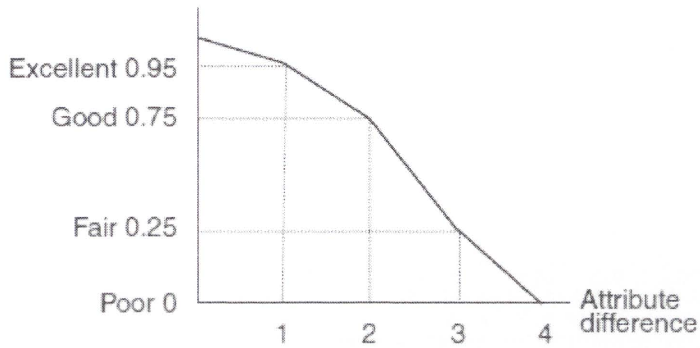


Figure 6.4: Example of the fuzzy preference function (Shiu & Pal 2004)

Table 6.2: Linguistic terms and similarity

Fuzzy Rating	Maximum Score	Minimum Score
Excellent	1	0.95
Good	0.94	0.75
Average/fair	0.74	0.25
Poor	0.24	0

The following is an illustrated example to explain the similarity concept on how to find the best matching cases. When the new case information is obtained, the Equations 6.2 to 6.10 can be used to calculate similarity based on data types. Suppose a given value is '130 injured', and the stored case has the following value '150 injured'. According to Equation 6.11:

Where *150 is* the value of the parameter i of the case j, *130* is the input value of the parameter i, W is the weight factor of the parameter $i = 10$. $max(C_i)-min(C_i)=50$ is the constant stand for the largest scope of the C_i of the case j. Therefore:

$$S_{IJ} = \left(\left| 1 - \sqrt{\left(\frac{150 - 130}{30} \right)^2} \right| \right) \cdot \frac{10}{10}$$

$$S_{IJ} = 0.6$$

This is repeated for all the given inputs parameters, and the average of similarity is calculated by Equation 6.10 for each selected retrieval parameter.

The retrieval algorithm works as follows: Once the case base has stored the historical data related to a given disaster situation, the system is ready to receive a new problem. When a new problem comes to the system, a search is made in the case base to retrieve all cases having s similar profile. The similarity of the new problem to the stored cases is determined by calculating the distance between case features. Then, after obtaining the most similar cases from the case base, the selected cases base will be used in the next phase (adaptation phase) to generate an accurate solution.

Algorithm 3: Case Retrieval Algorithm

Input: A new case C_i is described by a set of features, $\beta = \{\beta_1, \beta_2, ..., \beta_n\}$,
Where n is number of case features, i=1, 2 …., m. m is number o
f stored cases

Output: Similarity degree of a new case within the case base

Local variables: Old case C' is described by a set of features as follows:
$\alpha = \{\alpha_1, \alpha_2, ..., \alpha_n\}$, where n is number of case features, Data-type= {numeric, string, Interval, linguistic}, Weight (W) is the weight factor of the feature β such that W= $\{w_1, w_2 ... w_n\}$, Feature-function (F) is the function factor of feature β, such that F= {Equal, Threshold, Interval}, θ is a specified threshold value

Begin
Starting from i=1, select one case C_i $(0 \le i \le m)$
Begin
For each α_j *do* $(0 \le j \le n)$
Begin
Compute Similarity (S):
Case of (Feature-function =='Equal') do
if f_i (*data - type*) ='numeric' then do Equation 6.2
if f_i (*data - type*)='string' then do Equation 6.6
Case of (Feature-function =='Interval') do
Compute do Equation (6.3)

```
                Case of (Feature-function =='Threshold') do
                        Compute Equation (6.7)
                Case of (Feature-function =='Min and Max') do
                        Compute Equation (6.4 and 6.5)
                Case of (Feature-function =='Linguistic') do
                        Compute Equation (6.7 and 6.8)
        End
        Calculate the average of each retrieved case by Equation (6.1)
        Calculate the degree of similarity of retrieved case to a fuzzy set
        by Equations (6.8,6.9,6.10)
                if 0.95 ≤ S ≥ 1.0 then Similiarity is very high
              if 0.75 ≤ S ≥ 0.94 then Similiarity is high
              if 0.25 ≤ S ≥ 0.74 then Similiarity is fair
              if 0.0 ≤ S ≥ 0.24 then Similiarity is very low
    End
End
```

6.5.2 Case Adaptation

Case adaptation is the process of transforming the most similar cases retrieved from the case base into a solution appropriate for the current problem. Several strategies for case adaptation have been proposed in the literature. They can be classified in three main groups: substitution adaptation, transformational adaptation and generative adaptation. Our system uses substitution adaptation strategy. Substitution is used when parts of the old solution are conflict with or contradict the new problem requirements. For example, in disaster situation, part of an emergency rescue plan in the past may need to be replaced and updated with more effective and suitable plan for the current disaster situation. Substitution is performed by using a predefined semantic knowledge. The steps of the main adaptation algorithm used at each phase are described as follows: for every selected case in the retrieval phase, the distance between the case and its solution is calculated. If the difference of the proposed solution and those of the selected cases is acceptable, then solution is considered as a valid one, substitute the components violated using the predefined semantic knowledge and make other adjustments, if necessary. If not, the user is informed and the process goes to select new cases from the case base.

Algorithm 4: Case Adaptation Algorithm

Input: A new case $C' = \{f', \lambda', O'\}$ is described by the following attributes:

1) Set of features $f' = \{f_1', f_2', ..., f_n'\}$, where n is number of case features

2) Set of solution $\lambda' = \{\lambda_1', \lambda_2', ..., \lambda_k'\}$, where k is number of case solutions

A retrieved case $C_i = \{f, \lambda, O\}$ is described by the following attributes:

1) Set of features $f = \{f_1, f_2, ..., f_n\}$, where n is number of case features

2) Set of solution $\lambda = \{\lambda_1, \lambda_2, ..., \lambda_k\}$, where k is number of case solutions

Output: Case similarity/Case adaptation

Local variables: *PK* represents a set of constraints; *D* represents a set of differences attributes

Begin

Step 1. Retrieve the most similar case from the case base

Step 2. Determine the differences between cases, such that

$$d_i = f_i' - f_i$$

Where $d_i \in D\ for\ i = 1,2,3 \dots, n$, n is the number of features,

Step 3. $\forall d_i \in D$ Search for suitable substitution using predefined semantic knowledge and constraint (*PK*)

Step 4. Perform the substitution and make appropriate changes

End

6.5.3 Case Revise and Retain

A new disaster happened and is compared to a collection of significant disasters whose solutions are already known. The most similar significant disasters and the respective solution are retrieved. Then the solutions of retrieved cases are adapted to meet the new disaster situation requirements. The suggested solution is revised for its suitability by expert people. The revised solutions are then retained temporarily in the disaster database. When the suggested solutions are actually applied, the solutions outcomes for the current situation can then be evaluated. Finally, the new disaster description and its solutions are retained as a new case in the case base to help solving future disaster.

6.5.4 Situation Assessment

Situation assessment is responsible for assessing current decision situation and then aiding decision makers to develop their situation awareness (SA) of the disaster environment. From information system perspective, situation assessment is referred to as a data processing process during which data of interest is retrieved, analysed, presented, and understood by decision makers (Niu, Lu & Zhang 2008). The system employs the following criteria to measure key aspects of proposed solution:

- **Acceptability:** A solution is acceptable if it can meet the requirement of predicted situation, and can be implemented within time.
- **Adequacy:** a solution is adequate if it fulfils with applicable plan guidance.
- **Completeness:** A solution is complete if it integrates major actions, objectives and tasks to be accomplished.
- **Consistency:** A solution is consistent if it reliable with other related planning.
- **Feasibility:** A solution is considered feasible if critical tasks can be accomplished with the resources available internally.
- **Flexibility:** A solution is flexible if it easily deals with all hazards from smaller to wider incidents.
- **Interoperability:** A solution is interoperable if it identifies other stakeholders in the solution process with similar and complementary solutions and objectives.

6.6 Knowledge Presentation (Step 4)

This section is concerned getting the right information and knowledge to the right people at the right time in the right form. In an emergency situation, there is a need for rapid decision making under pressured dynamic conditions where information is partial, conflicting and often overloaded.

6.6.1 Identification of Need for Knowledge

6.5.1.1 Knowledge Need

Knowledge needs are used to find the right knowledge in case of sharing and to enable the creation of the right knowledge in the case of creation (Kucza 2001). Therefore, it is essential to specify the requirements of the needed knowledge, which facilitate an accurate search for knowledge or a creation of new knowledge.

Definition 6.2. Knowledge Need (KN)

$$KN = \{a'(S_i) | S_i \in SMS(T)\}$$

Where, S_i is a SMS text message of *SMS (T), a' (S_i)* is the local attribute of S_i, *i* is the number of SMS text message..

6.6.1.2 Organisation Profile

Organisation profile (OP) stands for a personalisation of a service that allows a user to query particular needs. An *OP* is a group of setting that defined how KP-MERS is set up for a specific user.

Definition 6.3. Organisation profile (OP)

$$OP = \{p, r, h\}$$

Where *p*, *r*, and *h* are denote a collection of personal data set of user requirements, and history activities respectively.

6.6.1.3 Determination of Knowledge Requirements

It is important to determine the desired type of knowledge needed. The requirements may include modules, processes and methods, which may have different specifications to describe them. The specification of need allows an accurate knowledge search or creation.

Definition 6.4. Knowledge Requirements (KR)

$$KR = \{T(S_i) | S_i = (s_i^1, s_i^2, .. s_i^n)\}$$

Where *KR* is knowledge requirement need, *T(Si)* is requirement type, and s_i^n is requirement steps, *i* is the i^{th} knowledge requirement need.

6.6.2 Knowledge Retrieval

The knowledge retrieval (KR) model is based on the information retrieval (IR) system. An IR system retrieves documents based on a user's query as input and the documents sorted by their relevance to the query (Ferrández 2011). The IR system is based on keyword indexing systems and Boolean logic queries that are sometimes supplied with statistical methods (Nasharuddin et al. 2010). A basic IR system is shown in Figure 6.5. The basic idea of the IR system is that the user asks the system and obtains desired information. The obtained information is then used to solve a given problem situation. A satisfactory problem resolution dismisses the information need.

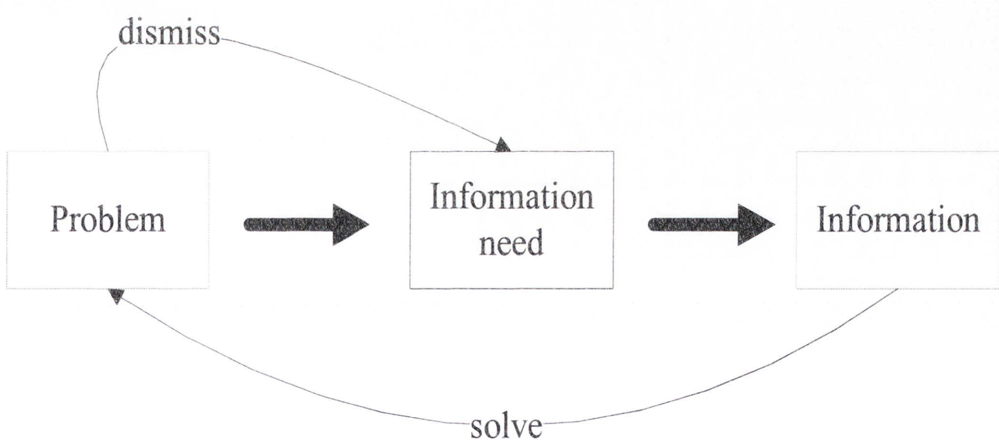


Figure 6.5: Information retrieval

The KR algorithm is described below.

Algorithm 4: Knowledge Retrieval

Input:
Let $R = \{R_1, R_2, \dots, R_n\}$ be a knowledge requirement
Let $OP = \{OP_1, OP_2, \dots, OP_k\}$ be an organisation profile
Let $CB = \{CB_1, CB_2, \dots, CB_n\}$ be an experience base
Output: Data warehouse
Begin
Step 1. Retrieve the most similar case from the case base based on knowledge requirement R_i and organisation profile OP_j. The Similarity is based on ontological similarity.
Step 2. Find the case with the max value of Sim(C,C')
Step 3. If $Sim(C, C') \geq \beta$ then Call *DW_Extraction* algorithm to extract concepts and insert them into data warehouse *DW*
End

6.7 Chapter Review

This chapter proposed a CBR-Ontology approach for a decision support system that can improve the efficiency of decision makers in an emergency situation. To achieve this, the CBR approach is combined with ontology. Ontology can provide a formal semantic representation of the objects for case representation. The proposed MERS has two main advantages: (1) It has the ability to use ontology-based similarity measures in order to avoid synonym problems and (2) It combines the CBR and ontology to integrate all the knowledge regarding emergency situation cases.

Chapter 7: The Prototype System—MERS

It's one thing to talk about them and have storyboards and another thing to see them for real.

Robert Hoekman

This chapter presents a prototype system as an implementation of the MERS framework. The developed prototype uses the IS techniques discussed in Chapters 3, 4, 5 and 6. The MERS enables the reception of SMS text messages from mobile users in an emergency situation. The prototype can be used to automatically extract many semantic elements of information in an emergency situation, including disaster location, disaster event and status of disaster. MERS has also been designed to support an emergency decision maker to effectively respond to an emergency situation. An organisation of this chapter is presented in Table 7.1.

Table 7.1: Organisation of Chapter 7

7.1	Introduction
7.2	MERS Prototype 7.2.1 Representation of Input Data 7.2.2 Storage System 7.2.3 Connectors 7.2.4 JAVA Method Library 7.2.5 Ontology Management 7.2.6 OBIE Tasks 7.2.7 OS-CBR Tasks
7.3	OBIE Application
7.4	MERS OS-CBR Application
7.5	Chapter Review

7.1 Introduction

To verify the usefulness of the proposed OS-CBR approach, a MERS prototype system has been developed using NetBeans IDE[6] under Microsoft Windows 7. The NetBeans project consists of an open-source IDE and an application platform that enables developers to rapidly create a variety of applications using the Java platform. The NetBeans is connected to a relational database management system (RDBMS) that is considered as a case library/table. MySQL[7] represents each table by an *.frm* table format (definition) file in the database directory. Structured query language (SQL) codes are embedded and used in the prototype system to play the role of RDMS for data retrieval and manipulation. MySQL can even modify the case structure while the system is running. Moreover, the efficiency of retrieval from the database is dramatically increased.

Section 7.2 describes the MERS prototype, Section 7.3 presents the OBIE application and Section 7.4 explains the potential MERS OS-CBR application. Finally, the chapter is reviewed in Section 7.5.

7.2 MERS Prototype

The prototype MERS is comprised of six subsystems: Storage System, Ontology Management, Connectors, Java Method Library, OBIE Tasks and OS-CBR Tasks. Each subsystem comprises a number of components, which are shown in Figure 7.1.

7.2.1 Representation of Input Data

Typically, in the context of m-Government, the input data of an OBIE is in the form of SMS text messages. The service allows the reception of SMS text messages from mobile phones. SMS text messages traditionally cannot exceed 160 characters, including spaces.

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[6] http://netbeans.org/

[7] http://www.mysql.com/

7.2.2 Storage System

The role of the storage system is to store all information about a disaster situation, which is the data source of IE processes and CBR processes. OBIE and OS-CBR must have access to the stored information in an efficient way.

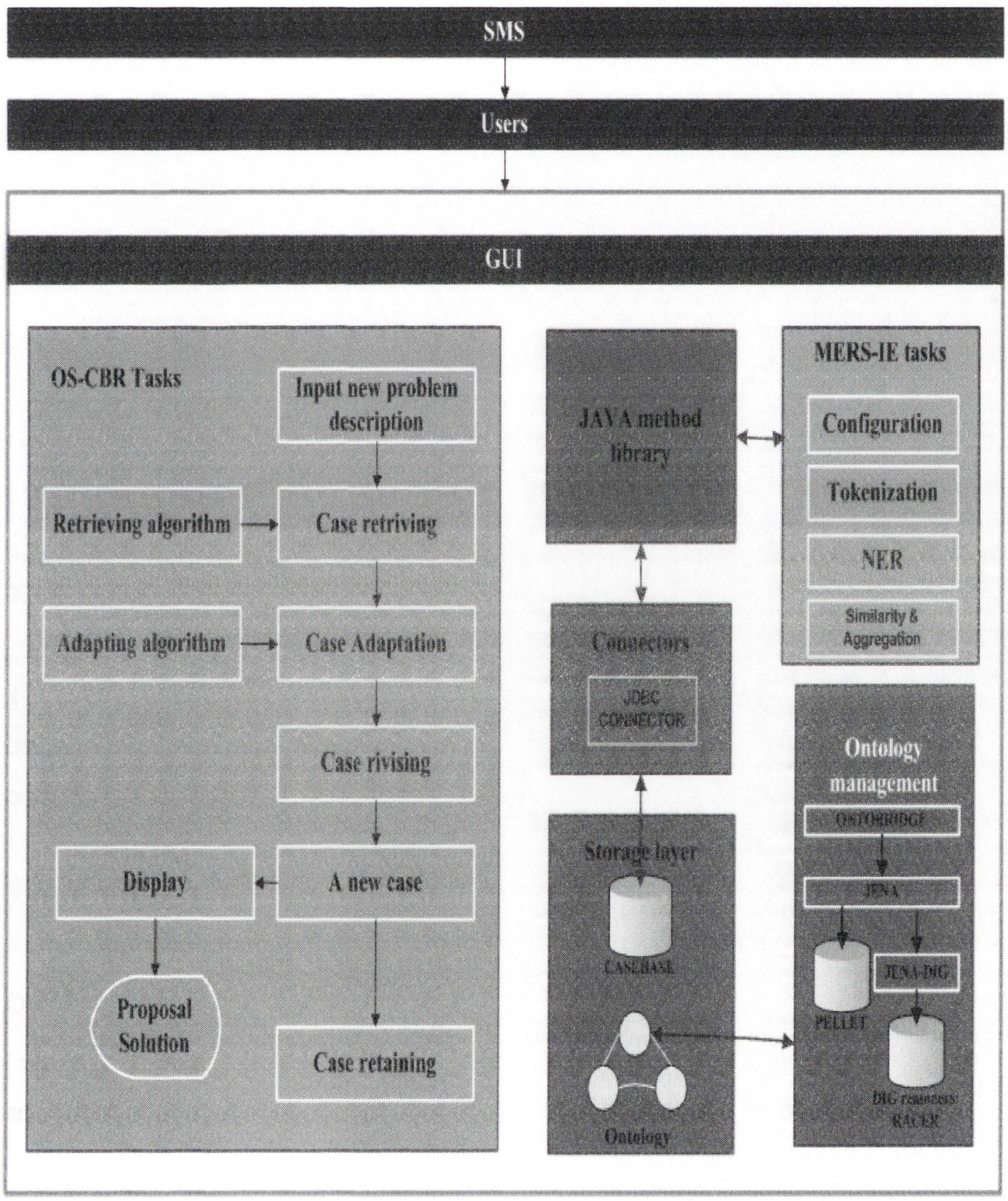

Figure 7.1: The architecture of the MERS prototype

7.2.3 Connectors

Java database connectivity (JDBC) provides a method for querying and updating data in a database. The example below shows the creation of a statement and establishes a database connection.

```
Connection conn = null;
Statement stmt= null;

try {
        String userName = "root";
        String password = "XXXX";
        String url = "jdbc:mysql://localhost:3306/smsmgs";
        Class.forName ("com.mysql.jdbc.Driver").newInstance ();
        conn = DriverManager.getConnection (url, userName, password);
        System.out.println ("Database connection established");
        stmt = (Statement) conn.createStatement();
 }catch (Exception e)

        {System.err.println("Cannot connect to database server!!!!");}
```

7.2.4 JAVA Method Library

The JAVA method library includes the operational level (i.e. the implementation) of IE methods and OS-CBR methods at the knowledge level. An IE system and OS-CBR Java code is written to include required resolution methods that the library does not contain.

7.2.5 Ontology Management

OntoBridge[8] Java library was used to facilitate the management of OBIE and OS-CBR ontology. OntoBridge is based on Jena 2.4,[9] allow access and store concepts, instances and properties. The ontology is saved into OWL RDF/XML files.

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[8] http://gaia.fdi.ucm.es/index.html
[9] http://jena.sourceforge.net/

7.2.6 OBIE Tasks

An IE application in MERS is defined at the knowledge level as a sequence of tasks that must be solved by a decomposition method. Decomposition methods divide a task into several subtasks such as pre-processing information, similarity measures and the presentation of results. For each task, a Java method is configured that solves it.

7.2.7 OS-CBR Tasks

A CBR application in MERS is defined as a sequence of tasks that are solved by a decomposition method. Decomposition methods divide a task into several subtasks such as retrieving, reusing, revising and retaining.

7.3 OBIE Application

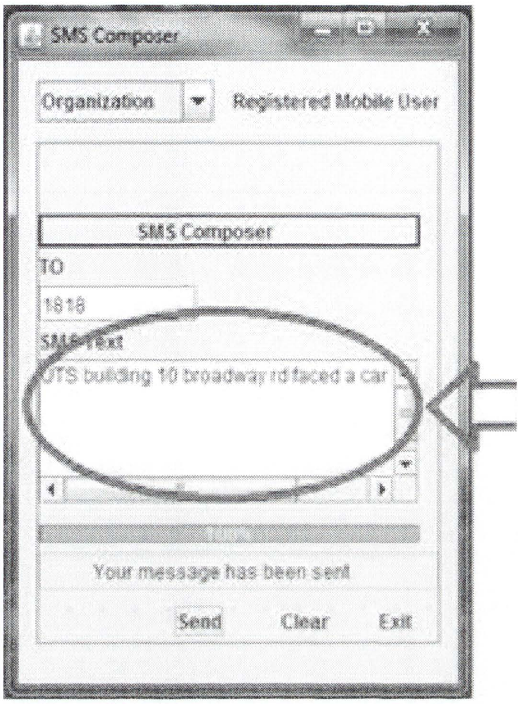
This section describes how an example is run through the system to help understand how it works. The application is built around the four classic steps in an IE cycle:

1. Collect unstructured information
2. conduct information extraction and aggregation
3. Calculate similarities
4. Generate queries and results.

The working process of using the OBIE is summarised into six steps as follows:

Suppose the system received the following SMS emergency text message from a mobile user as shown in Figure 7.2:

> There is a car bomb attack at UTS Broadway Rd. 3 students were killed and people were injured.



SMS Emergency Text Message

Figure 7.2: Client interface

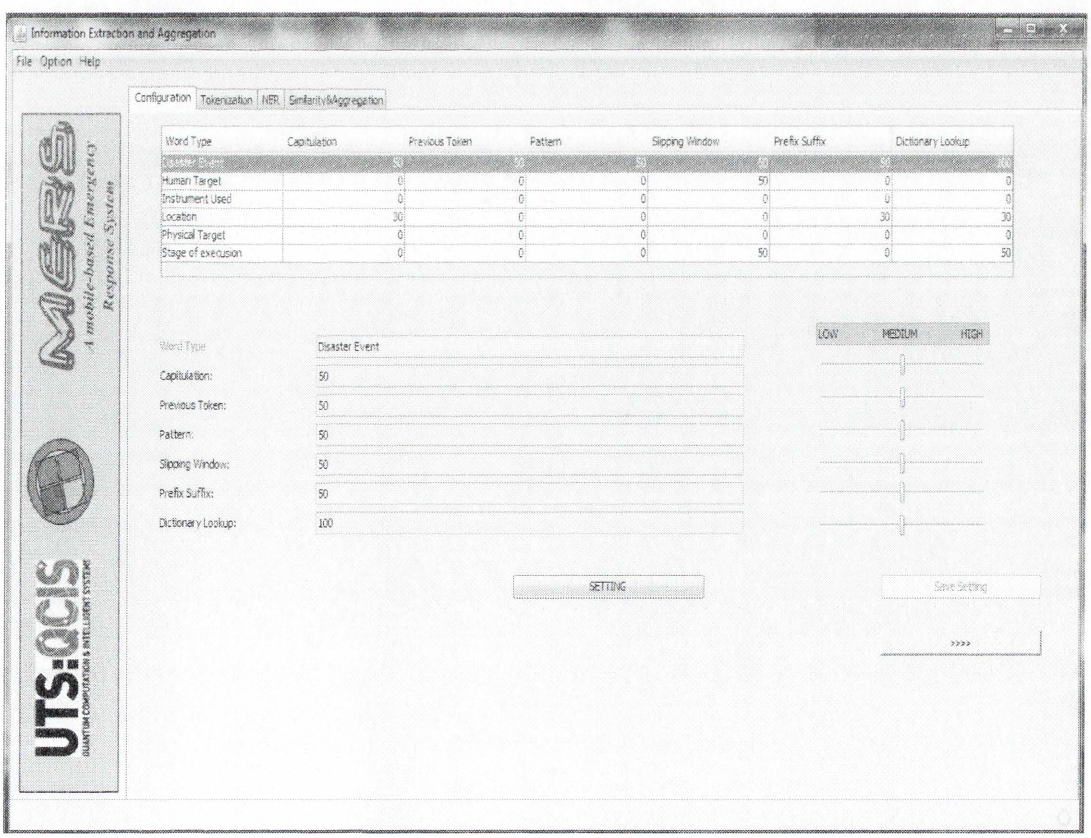


Figure 7.3: Configuration of features weight

Create a feature parameters weight for each target token as shown in Figure 7.3.Store the collected unstructured information of each individual SMS emergency text message in a database that contains SMS text ID, time, date SMS text and the sender's mobile phone number. Figure 7.4 presents a pie chart for the classification of received SMS text messages.

Perform IE algorithm. The first step is to break the text into words, or more precisely tokens, as shown at the top of Figure 7.5, and then apply NER processes. Calculate the similarity and aggregation of composite SMS text as shown in Figure 7.6.

Generate queries and results. Finally, the system generates an initial SMS emergency text message as shown in Figure 7.7.The following is an example of the warning message that will be automatically sent to mobile users:

> UTS building emergency at Building 10, if you are off campus, do not enter the campus. Wait for additional instructions.

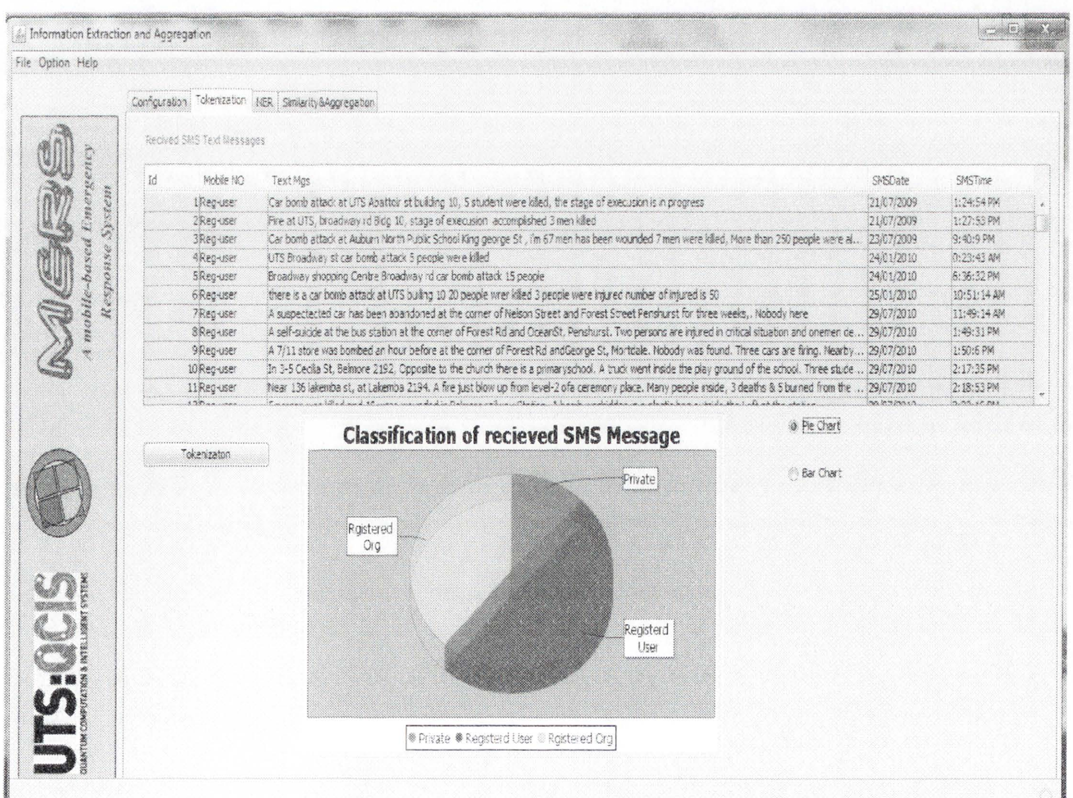


Figure 7.4: Received SMS text messages

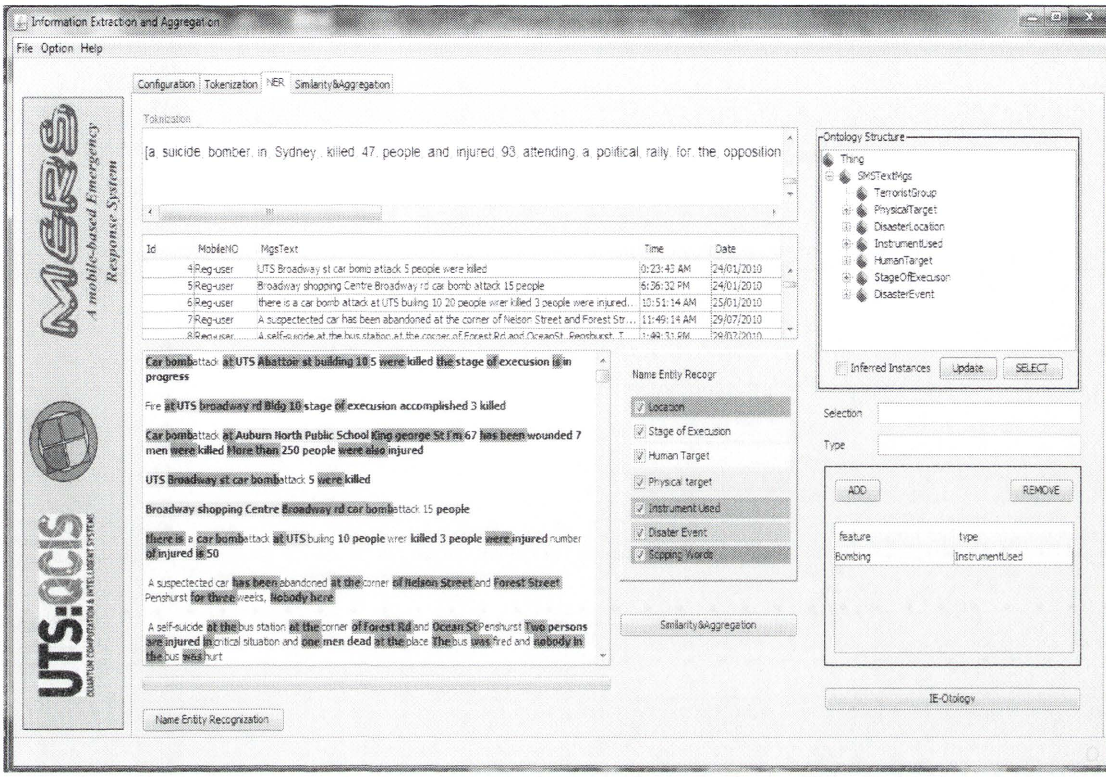


Figure 7.5: Tokenisation and NER processes

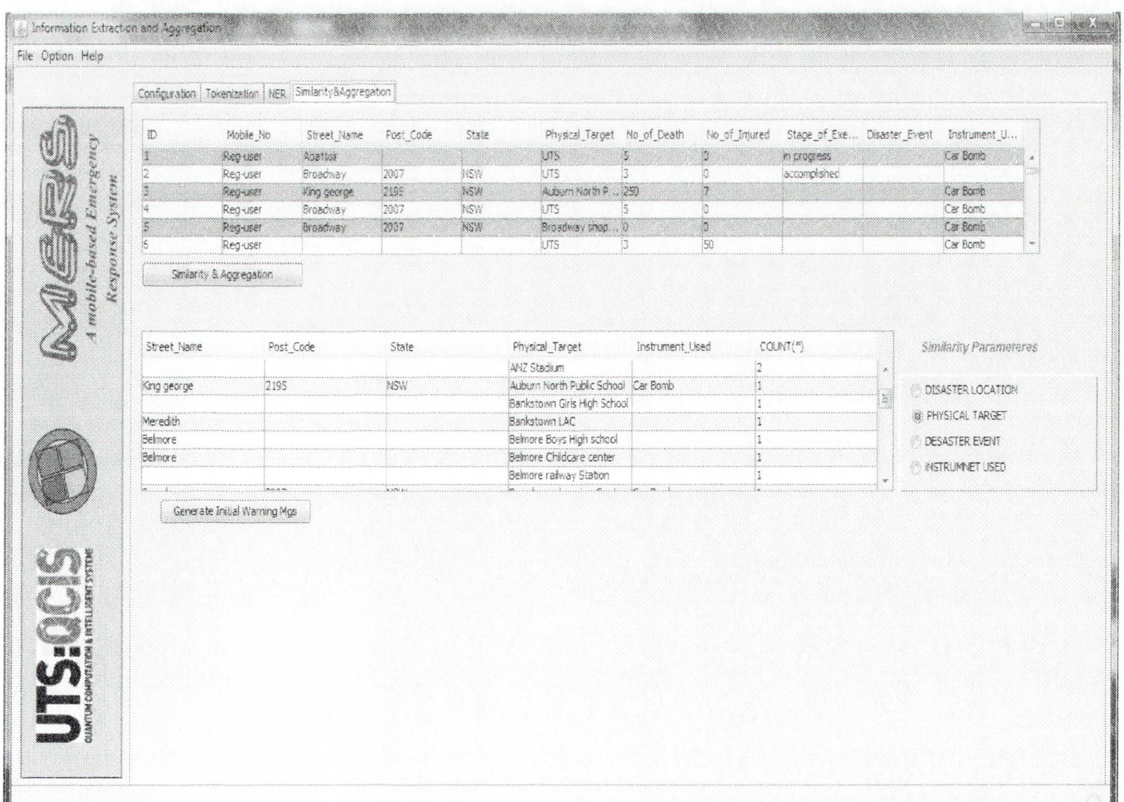


Figure 7.6: Similarity and aggregation process

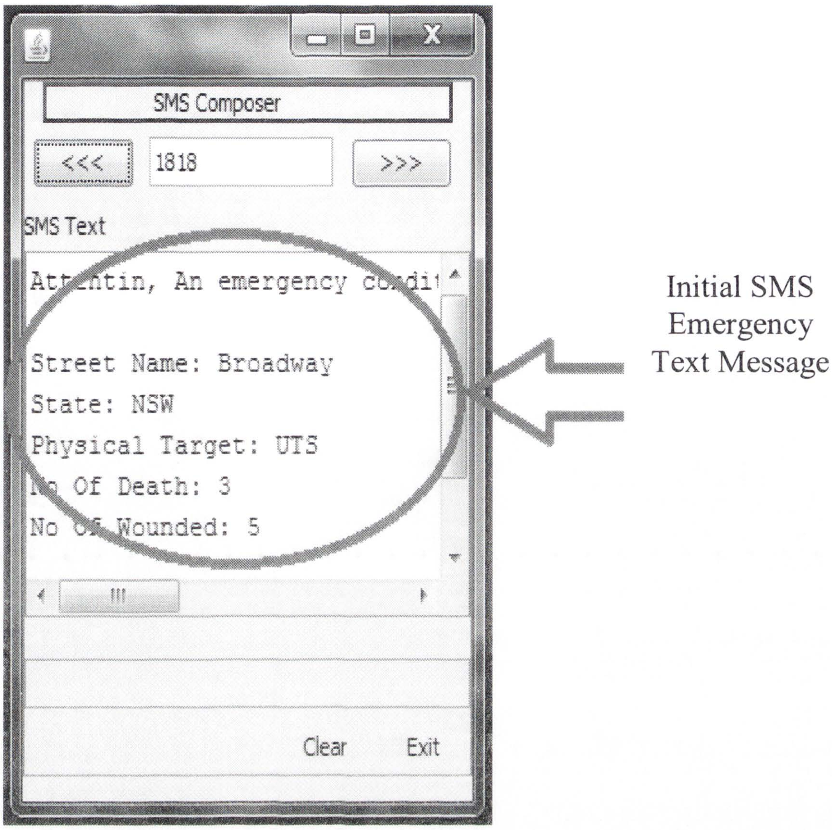


Figure 7.7: Client mobile interface for received an SMS emergency text message

7.4 MERS OS-CBR Application

The top area of the window contains tabbed panes so that several panes can share the same space: the user chooses which component to view by selecting the tab corresponding to the desired component. These components are configuration query, similarity configuration, case retrieval, case reuse, case revise, and case retain. Users use a query interface to input the requirements and run the system. The system retrieves data on problem description, solutions and outcomes from the case repositories to users (see Figure 7.8).

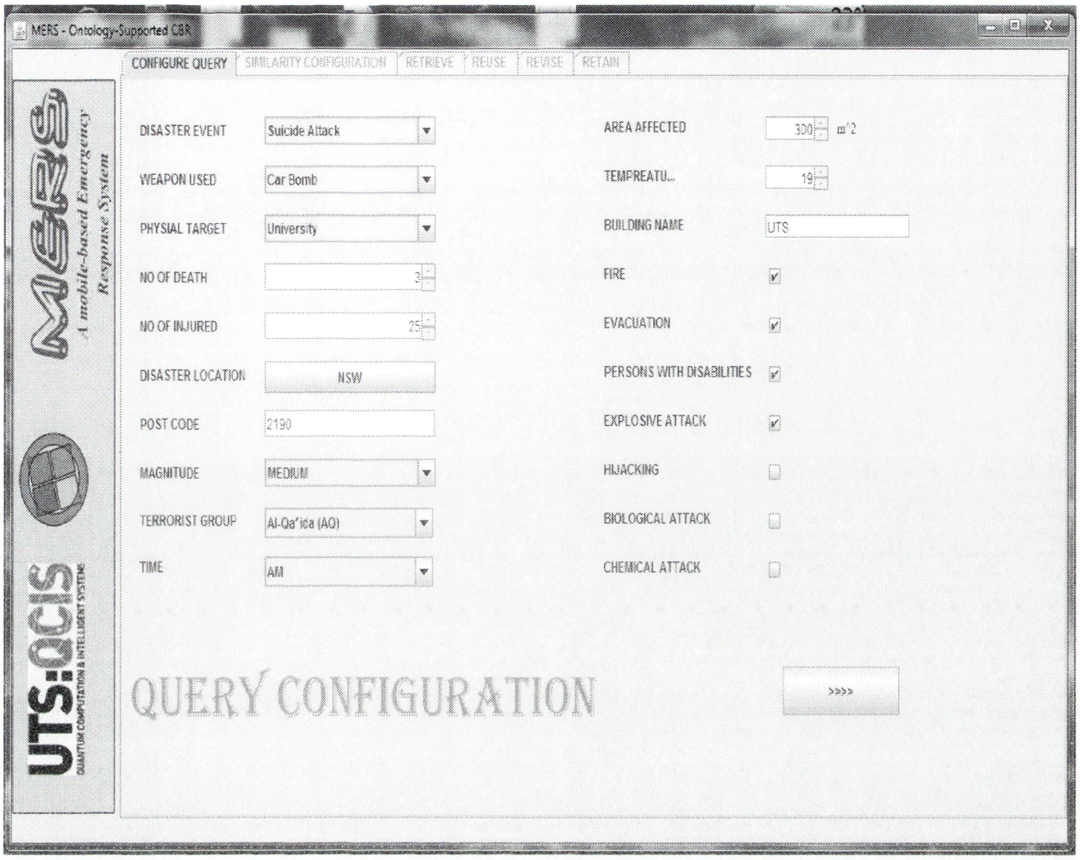


Figure 7.8: User disaster situation inputs interface

In this section, a CB example is given to illustrate the problem solving process for an emergency situation by using previous experience. The MERS system receives the mobile users messages and inserts them into a relational database. Figure 7.9 shows the input requirements of a disaster. For example, the name of the disaster is 'Suicide Attack', the weapon used is 'Car Bomb', the physical target is 'University', the number of deaths is '3', the number of people injured is '25', the disaster location is 'NSW', the size or magnitude of the disaster is 'Medium', the group responsible for this disaster event is 'Al-Qa'ida (AQ), the time the disaster occurred is 'AM', the area affected by the disaster is '$300m^2$', the temperature degree is '19', the area affected by fire is 'Yes', the building name is 'UTS', the area affected by fire is 'Yes, the evacuation of persons from a dangerous place due to a disaster event is 'Yes', the evacuation of a person with a disability is 'Yes', the use of explosive devices in the disaster is 'yes', the values of hijacking, biological attack and chemical attack attributes are 'No'.

After the user completes the inputs, he or she can choose the preferred attributes as shown in Figure 7.8. A vector of four elements is used to represent a case. The element of this vector describes the property (disaster attribute), its function, its importance within this case, and its value. The case and its elements are defined by the following equations.

$$C = \{f_1, f_2, \dots, f_n\} \tag{7.1}$$

$$f_i = \langle p_i, u_i, w_i, v_i \rangle, \; i = 1,2, \dots, n \tag{7.2}$$

Where p_i is the property name and its element is denoted by p_i = (disaster event, number of deaths, number of people injured, physical target, weapon used, disaster location), Feature-function (f_i) is the function factor of property p_i, such that u_i = {Equal, Threshold, Interval}. w_i is weight of f_i and v_i the value assigned to this property p_i.

In the similarity configuration (see Figure 7.9), the system allows the user to set the relative disaster features options for similarity purposes. These options are available by clicking on the corresponding check box. A Combo Box (a drop-down list of values), lets the user choose one of several choices of function property. The slider is used to set the weight value. A choice of six functions for the progression of weights from 100 (most important) to zero (irrelevant) is offered. The user can also control the value of function property that is displayed; for example, by setting the threshold value to a certain value. Spinner is used to allow the user to choose from a range of values to control the number of retrieved cases. The bottom right part of the window contains a button that the user can use to proceed to the retrieving cases stage.

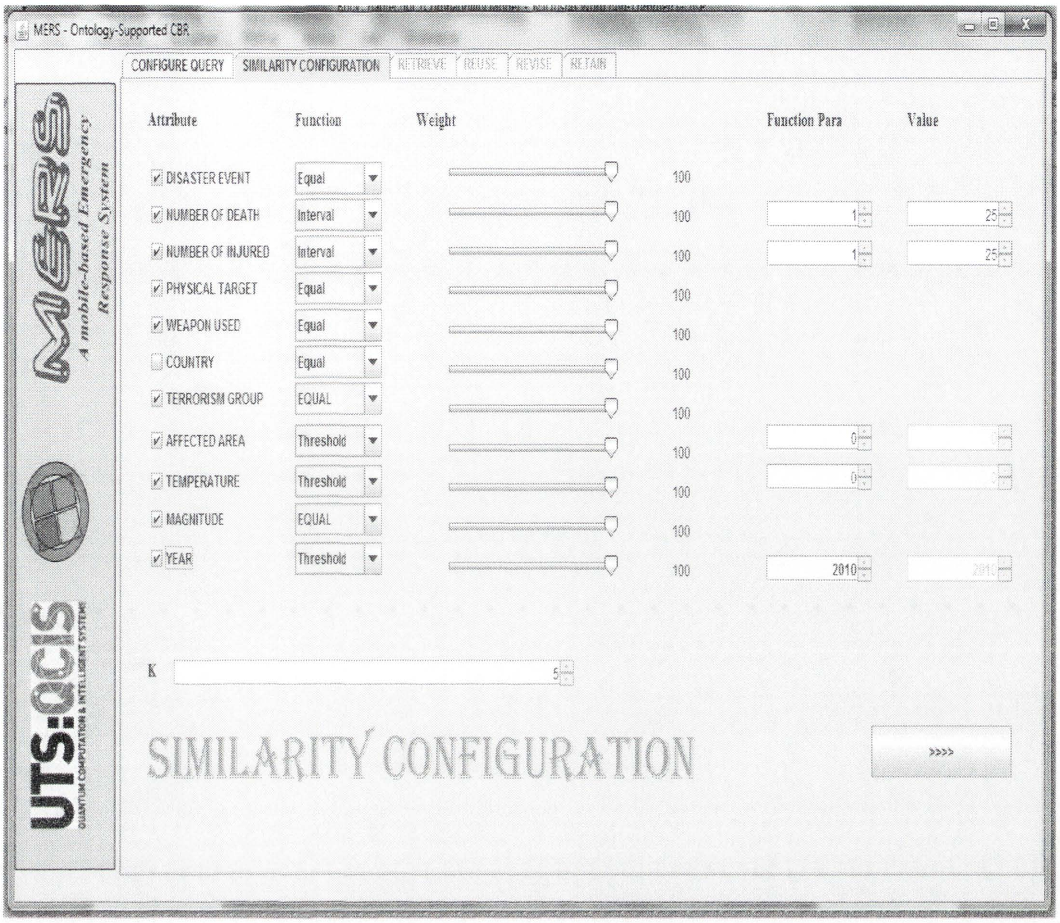


Figure 7.9: Similarity configuration values

The retrieving cases stage allows the decision maker to enter a query. Figure 7.10 shows the application interface. There are two ways to add case retrieval query values. Firstly, the 'Choose' button allows a decision maker to capture the terminological knowledge of the disaster domain. A new window shows the ontology tree where the user can select the query features. It is not mandatory to include every component. The user might enter a list of desired feature for the requested disaster situation. The user also might enter a list of un-desired features for the requested disaster condition. Secondly, each disaster situation belongs to general disaster events (e.g. 'Bioterrorism', 'Chemical Agent'), the disaster instrument used (e.g. 'Heavy weapon', 'Grenade attack'), disaster location (e.g. 'Africa', 'Asia') and the physical target of the disaster (e.g. 'Military', 'Civilian'). For example, if car bomb (weapon), educational building (physical target),and suicide attack (disaster event) are chosen as the desired disaster feature, the user might leave them unspecified. The two small checkboxes allow the user to specify that universal and/or common features might be assumed as available. When the user is finished or satisfied with his or her selection, the query button can be pressed in order to proceed to the next step.

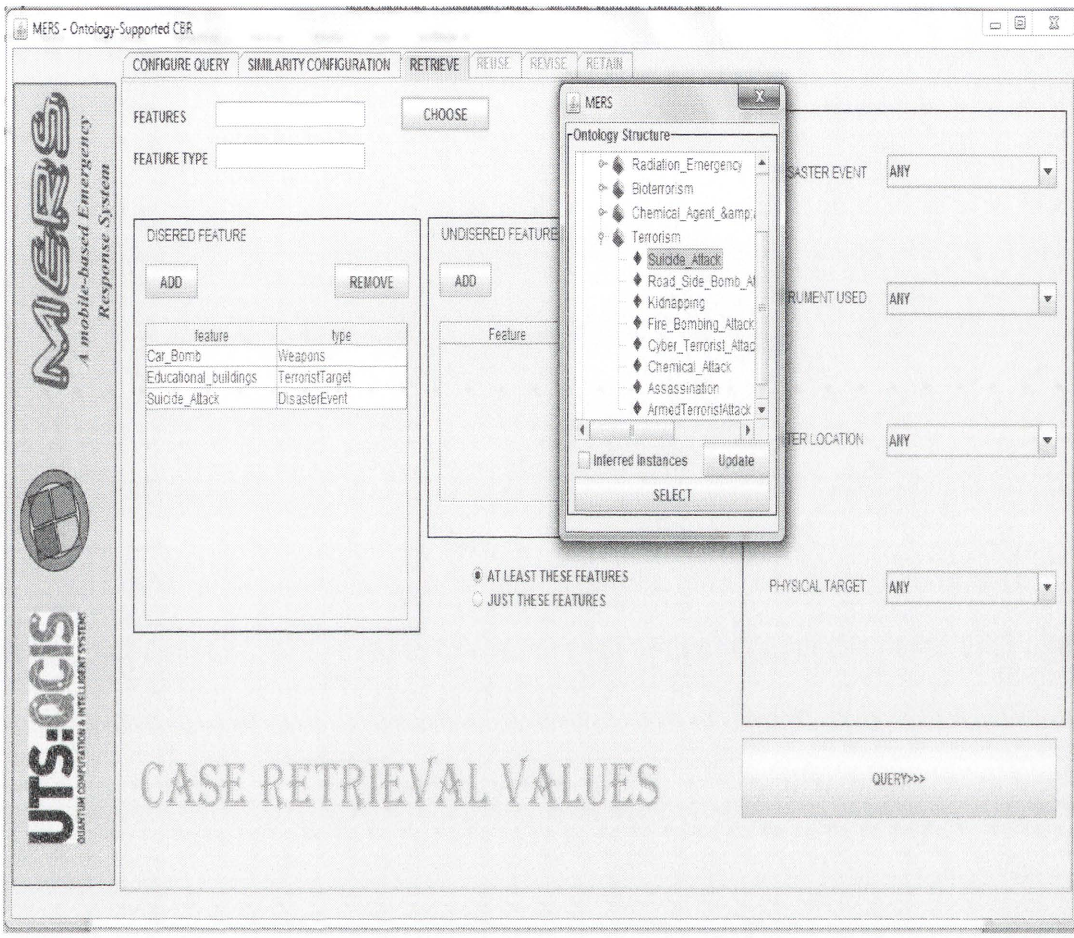


Figure 7.10: Case retrieval values

The case reuse stage (see Figure 7.11) allows the user to choose a disaster event from a list of *k* values most similar to the query (*k* is determined in the configuration similarity stage). The disaster events are sorted in descending order according to their degree of similarity to the current disaster condition. The 'select' button is used to proceed to the case revise stage.

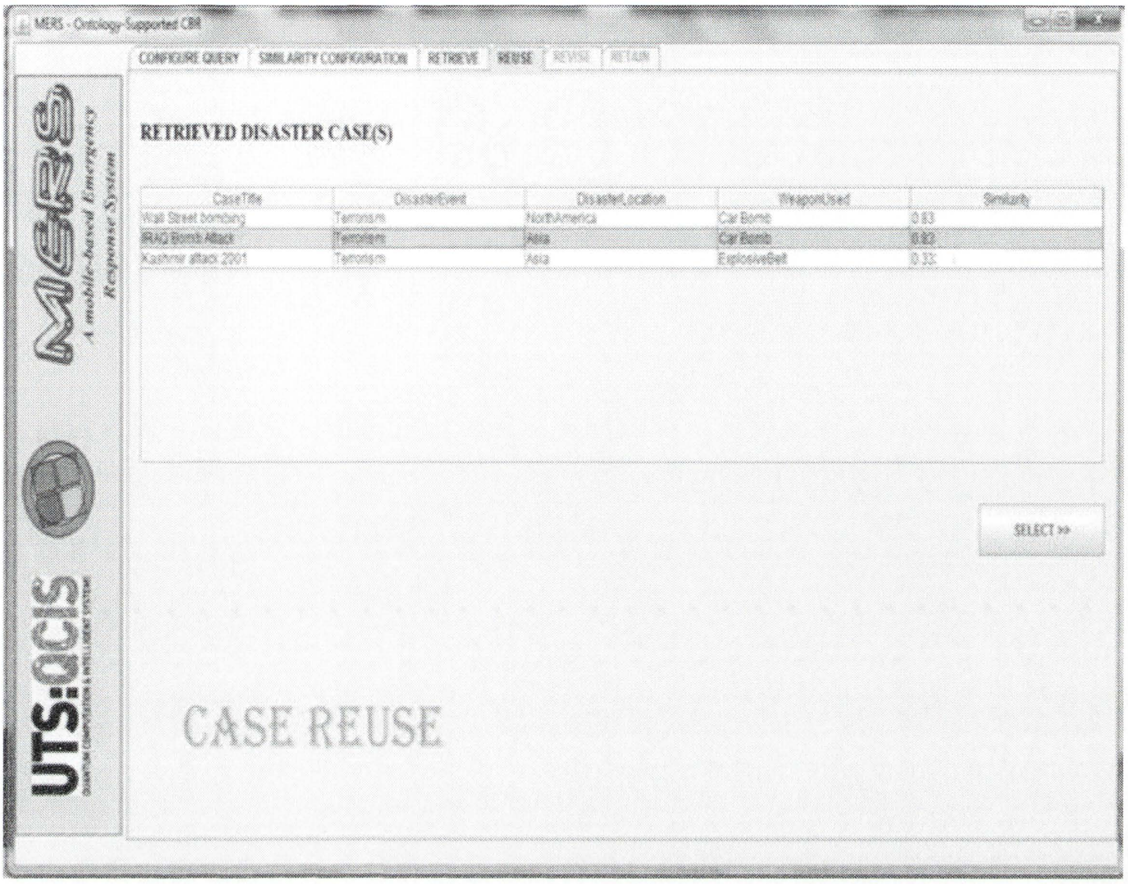


Figure 7.11: Case reuse

The next screen (see Figure 7.12) illustrates the user's selection of the disaster event case. The system performs adaptation tasks. In the example, the system has provided resource support groups that can be used as a substitution group. For instance, the system has substituted ABC Group by Disaster Resistant Communities Group LLC (DRC). Some other types have been changed according to the current disaster situation. In the example, chemical alerts and chemical attack plan are not required, so the system removes them from the solution part. In addition, the system shows the percentage values of key aspects of response planning. The top right part of the window contains a 'Done' button that the user can use to continue to the next and final stage (see Figure 7.13).

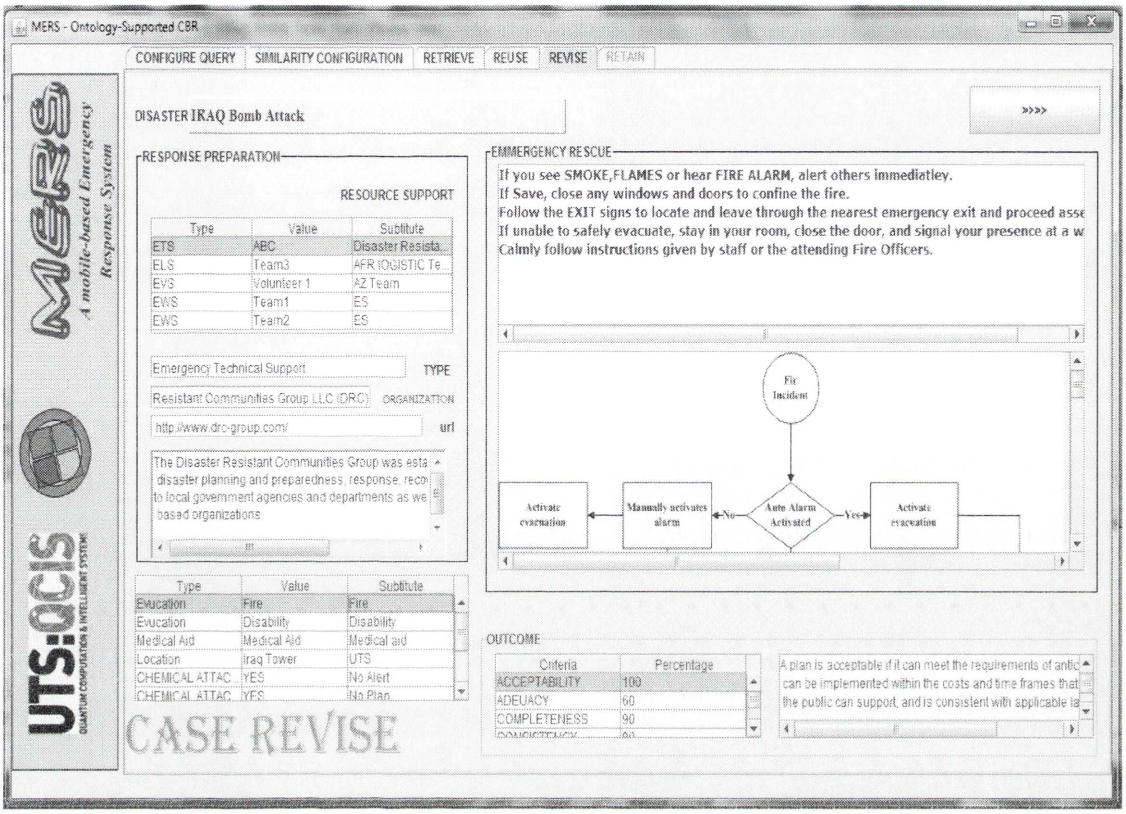


Figure 7.12: Case revision

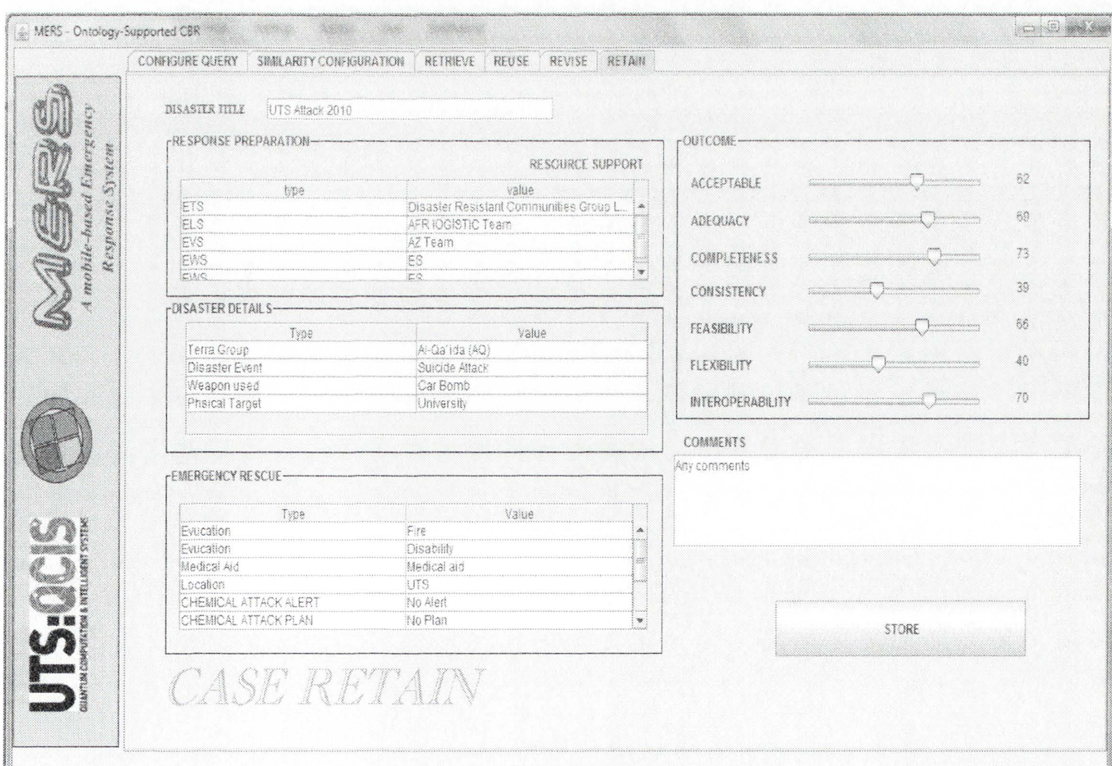


Figure 7.13: Case retain stage

The user might consider the proposed recommendation as a good solution to the current disaster situation. Then, the historical data can be retained in the case base for use in future queries using the rest of the CBR cycle. The top left area of the window contains a text field in which the user can enter a unique name for the new case. The top right part of the window contains a slider that allows the user to enter the criteria measurement of key aspects of the proposed solution.

7.5 Chapter Review

This chapter described the prototype system MERS, including its development environment, architecture and applications. MERS is the implementation of the IE and OS-CBR approaches and its primary objective is to support emergency response disaster processes using IS techniques.

In Chapter 8, MERS is used as a test bed to evaluate the IS techniques proposed in this thesis and details of the experiments are presented.

Chapter 8: System Evaluation

An evaluation system should be dynamic, highly interactive, and localised for each institution.

Larry A Braskamp

The objective of this chapter is to demonstrate how the prototype presented in the Chapter 7 works by experimenting with it on associated cases. The experiments will measure the classification effectiveness in terms of precision and recall. . An organisation of this chapter is explained in Table 8.1.

Table 8.1: Organisation of Chapter 8.

8.1	Evaluation of the MERS
8.2	Experiment Preparation
8.3	OBIE System Implementation 8.3.1 Text Collection 8.3.2 Results 8.3.3 OBIE Evaluation
8.4	MERS OS-CBR System implementation 8.4.1 Experiment I 8.4.2 Experiment II 8.4.3 OS-CBR Evaluation
8.5	Chapter Review

8.1 Evaluation of the MERS

This chapter reports on the experiments conducted to evaluate the algorithms and approach developed in this research. The aim of these experiments was to measure the performance of the MERS in terms of precision and recall, and F-measure. Section 8.2 provides experiment preparation. Section 8.3 describes OBIE system implementation and Section 8.4 presents the MERS OS-CBR system implementation. The chapter is reviewed in Section 8.5

8.2 Experiment Preparation

In this experiments, 20 subjects from Faculty of Engineering and Information Technology at the University of Technology, Sydney. There were two professors, and eighteen PhD students. All of them had two to five years of working experience in different industries. Before the experiment, a formal presentation was given to subjects to explain the functions and usage of MERS.

8.3 OBIE System Implementation

Automatic extraction of an SMS text message was evaluated using the standard information retrieval measures: precision, recall and F-measure. The recall score measures the ratio of the right information extracted from the texts against all the available information presented in the SMS text messages. The precision score measures the ratio of right information that was extracted against all the information that was extracted. F-measure is a combined measure of precision and recall (Katharina, Cem & Silvia 2007).

Let us assume N is a collection of SMS text messages. In this collection, n represents all the specific relevant information that must be extracted (disaster location, weapon used, physical target, stage of execution, stopped words), and r all the specific relevant information extracted manually. The IE system recognises a collection of SMS text messages and in this collection k represents all results extracted. The recall (R), precision (P), F-measure and overall accuracy (OA) formulae used are given by equations as follows.

$$Recall\ (R) = \frac{a}{a+c} \tag{8.1}$$

$$Precision\ (P) = \frac{a}{a+b} \tag{8.2}$$

$$F - measure = \frac{2RP}{R+P} \tag{8.3}$$

$$Overall\ Accuracy\ (OA) = \frac{a+b}{N} \tag{8.4}$$

Table 8.2 summarises the relationships between the system classifications and the expert judgments in terms of a binary classification.

Table 8.2: Contingency table of class of classification and decisions

Expert / IE system	Relevant	Not-relevant	Total
Matched	a	b	a+b=k
Not-matched	c	d	c+d=n-k
Total	a+c=r	b+d=n-r	a+b+c+d=N
Overall accuracy (OA)= (a+b)/N			

Where n = number of classified objects, k = number of objects classified into specific relevant information to be extract by the system, r = number of objects classified into specific relevant information to be extracted by the expert.

8.3.1 Text Collection

A total text collection of 100 SMSs is manually generated. In this collection, the use of unnecessary information is avoided, messages are kept brief and comply with the 160-character limitation, use direct, straightforward language and communicate all necessary actions. The SMS text collection is composed of 2851 words.

8.3.2 Results

The system was tested with information consisting of five classes: disaster location, human target, physical target, weapon used, and disaster event. The results of two types of information are summarised in Tables 8.3 and 8.4 respectively. The extracted instances were first compared automatically to compute precision and recall.

Table 8.3: Evaluation metrics for disaster location

IE system \ Expert	Relevant	Not Relevant	Total
Matched	96	2	98
Not-matched	6	0	6
Total	102	2	104
Recall	**0.94**		
Precision	**0.97**		
F-measure	**0.95**		

Table 8.4: Evaluation metrics for weapon used

IE System \ Expert	Relevant	Not-relevant	Total
Matched	42	0	42
Not Matched	14	0	14
Total	56	0	56
Recall	**0.75**		
Precision	**1.00**		
F-measure	**0.85**		

The system suggests that overall the entity extraction system correctly locates and classifies disaster location. Precision exceeds recall by 3% (Precision=97%) as shown in Table 8.3. In Table 8.4, the system suggests that precision exceeds recall by 25% (Precision=100%) for the weapon used and this variance is statistically significant. The standard measures for evaluating the performance of the system can be seen in Figure 8.1.

Figure 8.2 presents the system classification results side by side. The right bar represents all instances of the disaster location entity. The left bar represents the ratio of accurate results and the different types of classification. Figure 8.4 illustrates the number of correctly found and classified entities (black section of left bar), the number of correctly classified and misclassified entities (gray section of left bar), and the number of false positives with respect to identification and classification (white section of left bar). On average, the system correctly classified 92.30 per cent of the instances of the disaster location entity in the data, while 1.92 per cent of the entities suggested by the system were false positive. At the same time, the system failed to correctly classify 5.76 per cent of the disaster location entity in the data.

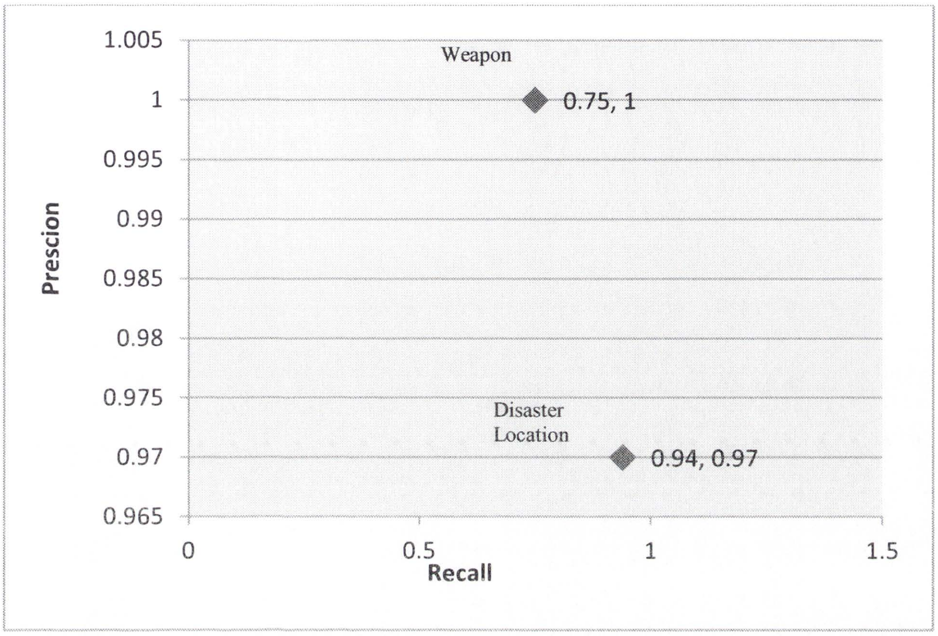


Figure 8.1: Frequency of disaster location entity

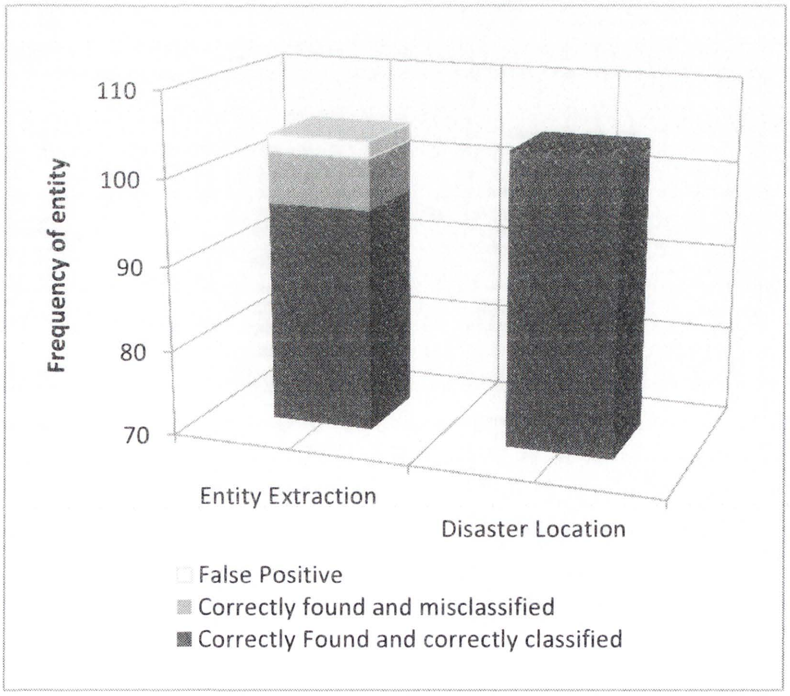


Figure 8.2: Frequency of disaster location entity

Another example of entity extraction is illustrated in Figure 8.3. On average, the system correctly classified 75 per cent of the instances of the weapon used in the data, and zero per cent of the entities suggested by the system are false positive. At the same time, the system failed to correctly classify 25 per cent of the weapon used entity in the data.

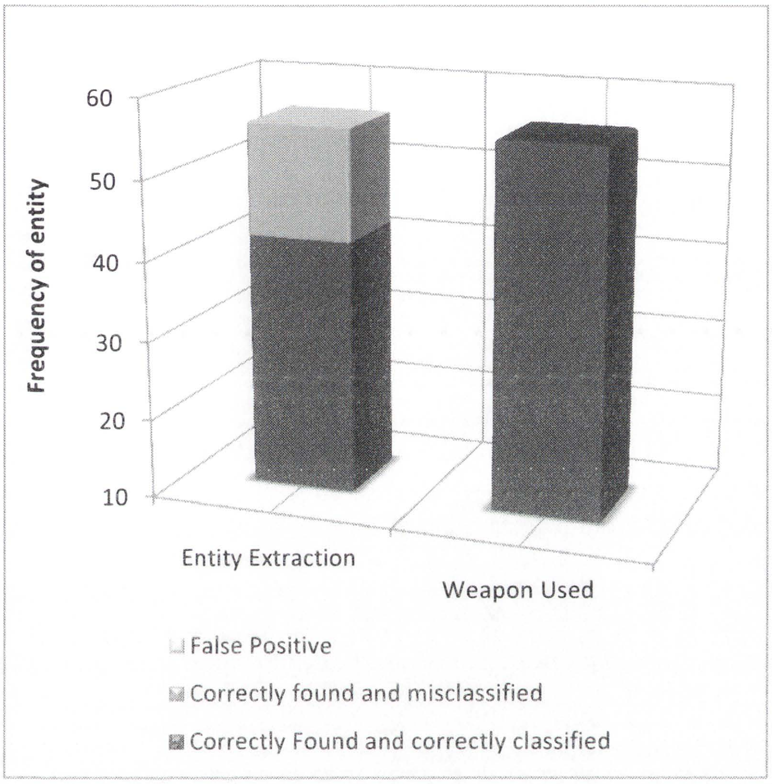


Figure 8.3: Frequency of weapon used entity

To summarise, the average overall of extracting six categories is shown in Table 8.5. The system suggests that overall entity extraction precision exceeds the recall by five per cent.

Table 8.5: Accuracy of entity extraction

	Recall	Precision	F-measure
Average	0.92	0.98	0.95
Maximum	1.00	1.00	1.00
Minimum	0.75	0.95	0.84
Standard Deviation	0.09	0.02	0.05

The left bar of Figure 8.3 represents all instances of extracting six categories in SMS text. The right bar represents the ratio of the system's accurate results. Overall, the system correctly identified and classified 95 per cent of the instances of the categories contained in an SMS text (F-measure value as shown in Table 8.5). At the same time, the system fails to correctly recognise 2.98 per cent of the entities contained in an SMS text, and misclassifies 4.54 per cent of the correctly recognised entities. As illustrated in Figure 8.4, the number of correctly classified entities (black section of left bar) plus the number of misclassified entities (grey section of left bar) plus the number of false positives (white section of left bar) equals the number of all entities in an SMS text (entire right bar). Figure 8.5 presents the total frequency of terms per category in the test data.

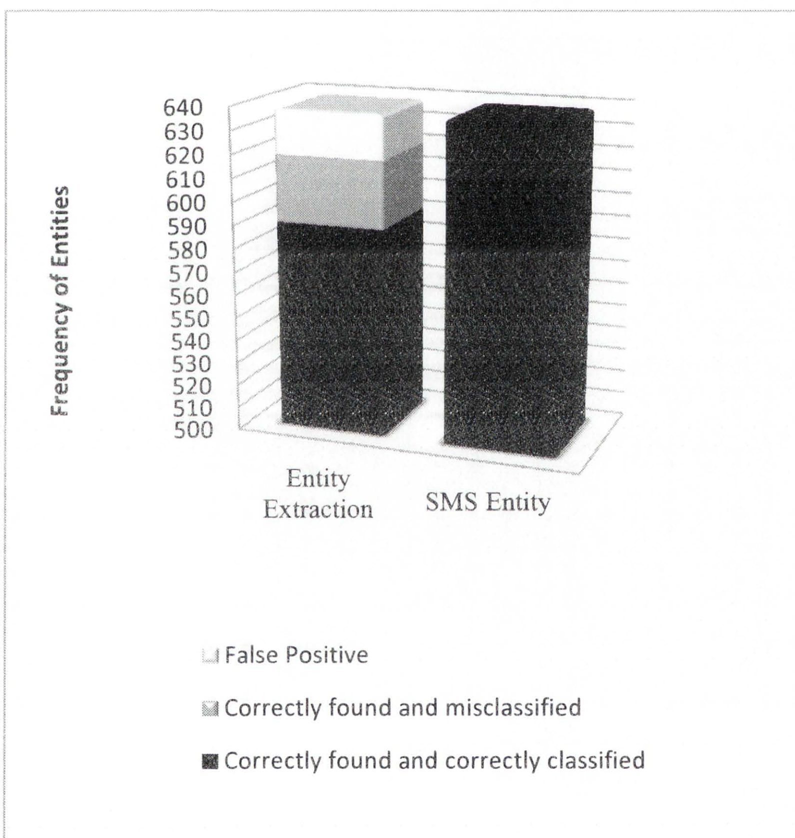


Figure 8.4: Frequency of entities and type of errors

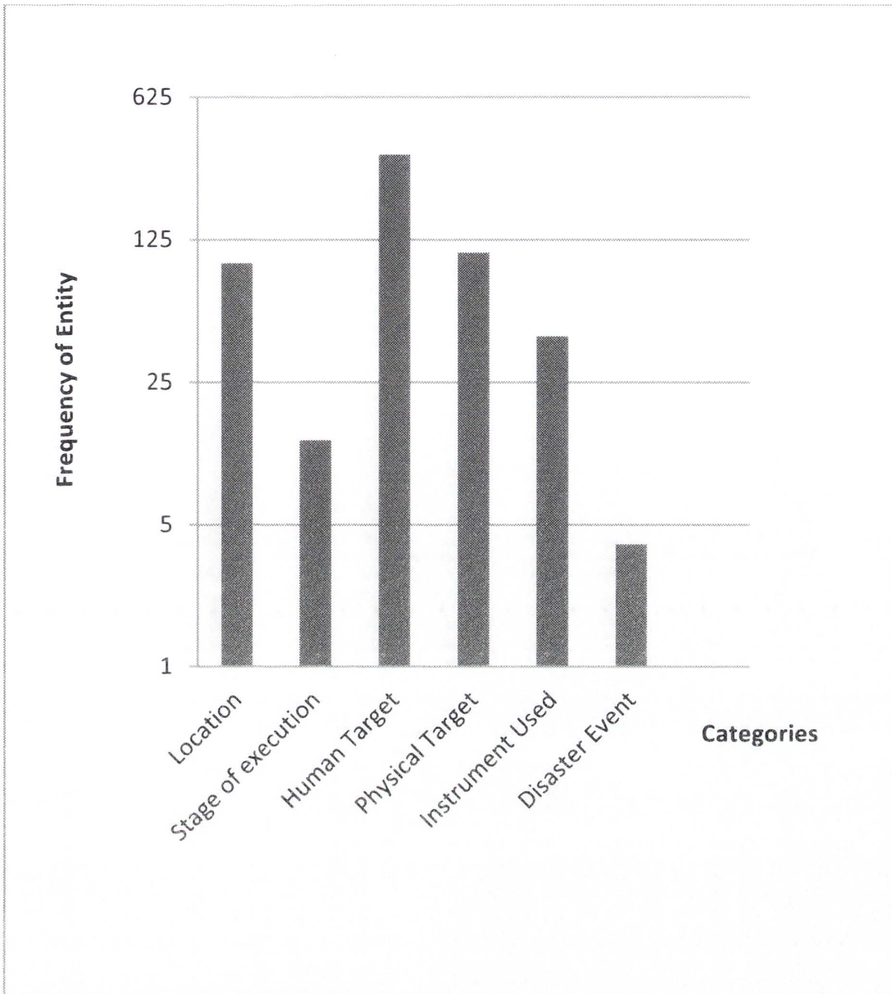
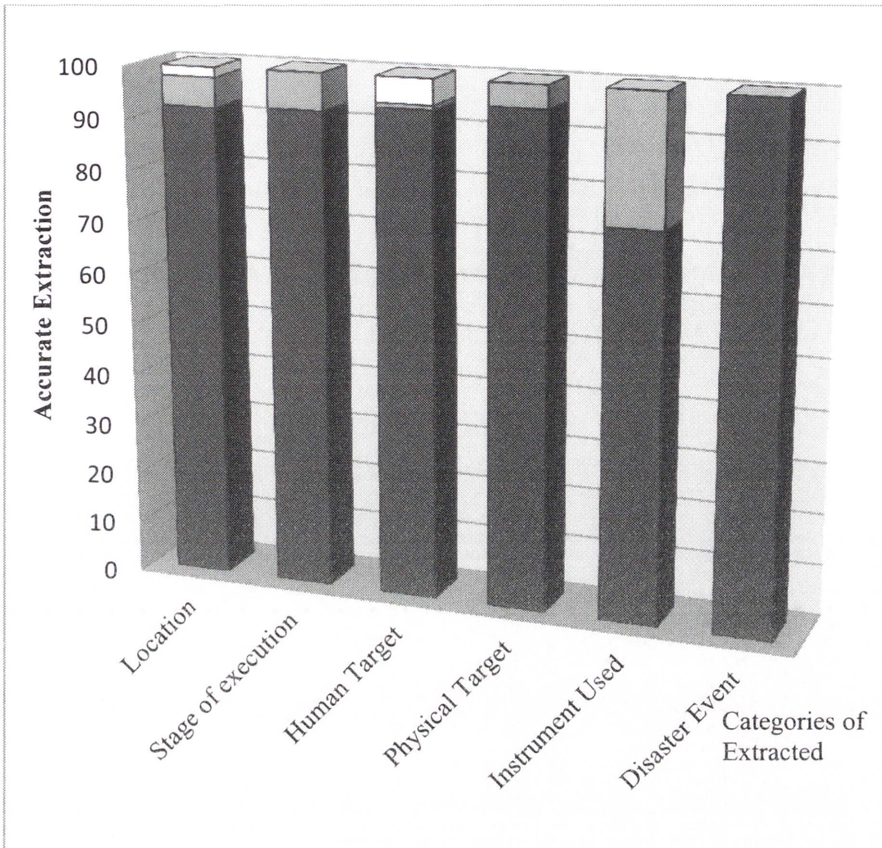


Figure 8.5: Frequency of entities per category

The distribution of accuracy rates for each category considered by the system is summarised in Figure 8.6. The y-axis (100%) in Figure 8.6 presents the accuracy rate results with the misclassified and false positive classifications. The system suggests that the 'instrument used' instance has the lowest accuracy rate with 75 per cent, while 'location', 'stage of execution', 'human target', 'physical target', and 'disaster event' instances exceed 90 per cent of the accuracy rate in the test data. The system suggests that the 'human target' instance misclassifies 4.89 per cent of categories contained in an SMS text.



	Location	Stage of execution	Human Target	Physical Target	Instrument Used	Disaster Event
□ False Positive	1.92	0	4.89	0	0	0
Correctly found and misclassified	5.76	7.14	0.86	4.42	25	0
Correctly found and correctly classified	92.3	92.85	94.23	95.57	75	100

Figure 8.6: Frequency of entities per data set

8.3.3 OBIE Evaluation

Table 8.5 reflects the survey form that questions filled out during the experiments, the performance of OBIE as a whole was evaluated. In the Table 8.5, the mean rating and standard deviation (SD) for each survey question (statement) were calculated. Questions were categored into three grouped: *IE tasks*, *Overall* and *disaster information presentation*. Each question evaluates OBIE based either on information usefulness perspective or on information usability perspective.

In question 1 of Table 8.6, subjects agreed, using SMS text messages, that mobile users could easily describe their disaster situation and them to MERS. The SMS text interface is important for emergency response system. MERS allows mobile users to describe their disaster situation using natural language or specific key words. Using natural language or key words, mobile users can freely describe and send whatever; they think significance and valuable to their disaster situation.

The overall rating of MER-IE in IE task process evaluation is 4.34. This indicates that OBIE is an affective way to extract information from SMS messages in disaster situations. In particularly, OBIE could recognize the name entity (e.g. Location) correctly with average rating of 4.55 (Question 2 of Table 8.5), and OBIE can obtained SMS messages similarity and aggregation correctly with average rating of 4.18 (Question 7 of Table 8.6).

OBIE received an overall rating of 4.39 in disaster information presentation. Subjects in the experiment agree that the generated SMS helped to come up with faster and well-planned actions with average rating of 4.82 (Question 9 of Table 8.6).

In the overall rating of OBIE, evaluation is 4.45. OBIE helped to get information rapidly with average rating of 4.73 (Question 11 of Table 8.6), and overall satisfaction with information extracted results with average rating of 4.18. . OBIE helped to obtained valuable information more effectively with average rating of 4.64 (Question 15 of Table 8.6). , and OBIE helped to obtained valuable information more efficiently with average rating of 4.45 (Question 16 of Table 8.6).

In terms of usefulness, the overall average rating of OBIE is 4.45, which reflects the information presented by OBIE is helpful for emergency response system in disaster situation. In terms of usability, the overall average rating is 4.34, which reflects the information generated by OBIE is easy to use for emergency response system.

OBIE is an implementation of the IE approach. The ultimate goal of OBIE is to extract valuable information from SMS text with satisfaction results (Question 13 of Table 8.6). In this sense, the argument of OBIE is achieved.

Table 8.6: OBIE Performance

STATEMENT	Subjective rating[10]	Mean rating	Standard deviation
IE TASKS			
1. Given a disaster situation, I can precisely describe my situation using SMS text.	2	4.18	0.60
2. OBIE recognize the name entity(e.g. Location) correctly	2	4.55	0.52
3. OBIE can recognize irrelevant results	2	4.27	0.65
4. MERS helps to find the suitable terms for a particular corpus.	2	4.27	0.47
5. OBIE helps to find relations' identification between entities	2	4.45	0.69
6. Rate your overall satisfaction with the extraction results	2	4.45	0.52
7. OBIE obtained SMS similarity and aggregation correctly	2	4.18	0.40
DISASTER INFORMATION PRESENTATION			
8. The generated SMS help me to understand the current disaster situation	1	4.18	0.60
9. The generated SMS help me to come up with faster and well-planned actions	1	4.82	0.40
10. Rate your overall satisfaction with the generated SMS emergency details	1	4.18	0.40
OVERALL			
11. OBIE helps me to get information rapidly	1	4.73	0.47
12. OBIE system easy to learn	2	4.27	0.65
13. Rate your overall satisfaction with information extracted results	1	4.18	0.60
14. the user interface of OBIE is user friendly	2	4.45	0.67
15. OBIE helps me to obtain valuable information more effectively	1	4.64	0.50
16. OBIE helps me to obtain valuable information more efficiently	1	4.45	0.52

8.4 MERS OS-CBR System Implementation

This section presents some results of the experiments conducted to examine the performance of the approach. The approach was evaluated using the standard

[10] Usefulness: 1; Usability: 2

information retrieval measures: precision, recall and F-measure. The recall score measures the ratio of the relevant information retrieved from the cases against all the available relevant information present in the cases. The precision score measures the ratio of relevant information that was retrieved against all the information that was retrieved. F-measure is a combined measure of precision and recall.

Let us assume *N* is a collection of cases. In this collection, *n* represents all the specific relevant information to be retrieved, such as disaster location, weapon used and physical target), and *r* the right specific relevant information retrieved. The OS-CBR approach recognises a collection of cases. In this collection, *k* represents all results retrieved. Then the recall (R), precision (P), and F-measure formulae used are given by equations 8.5 to 8.8. Table 8.7 summarises the relationships between the precision and the recall in terms of a binary classification.

Table 8.7: A contingency table analysis of OS-CBR precision and recall

Expert / IE system	Relevant	Not-relevant	Total
Retrieved	a	b	a+b=k
Not-Retrieved	c	d	c+d=n-k
Total	a+c=r	b+d=n-r	a+b+c+d=N
Overall accuracy (OA)= (a+b)/N			

$$Recall\ (R) = \frac{Relevant\ and\ Retrived}{Relevant}$$

$$= \frac{a}{a+c} \tag{8.5}$$

$$Precision\ (P) = \frac{Relavant\ and\ Retrieval}{Rtrieved}$$

$$= \frac{a}{a+b} \tag{8.6}$$

$$F - measure = \frac{2RP}{R+P} \tag{8.7}$$

$$Overall\ accuracy\ (OA) = \frac{a+b}{N} \tag{8.8}$$

Table 8.8 contains four main columns. The column 'Number of Attributes', indicates the significant attributes of the environment that describes the surroundings of the problem. The column 'Cases', indicates the cases that were tested to verify the performance and capabilities of the proposed approach for supporting decision making in disaster situations. Experiments were conducted utilising nine different numbers of attributes (2, 3, 4, 5, 6, 7, 8, 9, and 10) and three different cases (Case I, Case II, and Case III). The columns 'CBR' and 'OS-CBR' contain sub-headings including 'Precision', 'Recall', 'F-measure' and 'Overall Accuracy' to indicate the OS-CBR's performance. All graphs provided in this section are based on Table 8.8.

This study tested the proposed OS-CBR approach in an experiment. There are three cases in the emergency response database. Each case contains 12 attributes: Case ID, Case Title, Disaster Event, Weapon Used, Disaster Location, Number of Injured, Number of Dead, Affected Area, Temperature, Terrorism Group, Magnitude and Date. From the database, the OS-CBR tried to produce an emergency response plan with recommendations subject to the input user's conditions. The OS-CBR would recommend reasonable reference cases to the decision maker based on a user's input features.

8.4.1 Experiment I

In the first experiment, the effect of the number of attributes on cases retrieved for the CBR approach was examined as shown in Figure 8.7. Each of these nine graphs shows precision is affected by the number of attributes, while recall stays firmly at 100 per cent across all the number of attributes. Several tests were conducted to verify the performance of the CBR approach, two of which are presented here.

First, two features were considered as target, including 'disaster event' (e.g. suicide attack), and 'physical target' (e.g. university). Their weights were set at 100 per cent.

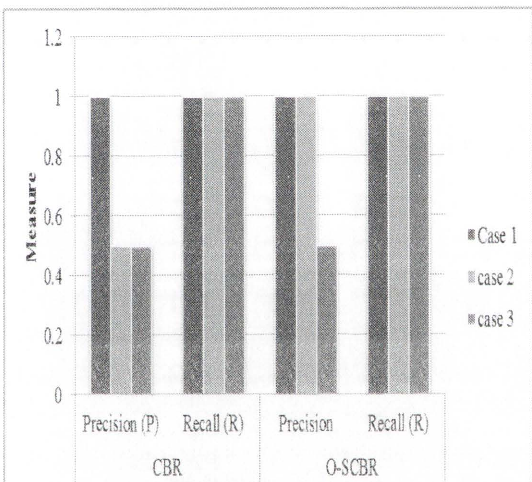
CBR would retrieve three cases, two of which were perfectly matched with target features. According to Table 8.8, CBR is able to retrieve a recommended case at a precision and a recall of 100 per cent, and two other cases at a precision of 50 per cent. The result is shown in Figure 8.7 (1).

Second, one more attribute, 'terrorism group' (e.g. Al Qaida), was added with a weight of 100 per cent. CBR would retrieve two cases at a precision of 67 per cent, and one case at a precision of 33 per cent. Figure 8.7 shows the precision and recall scores for k-attributes, where *k*=3, 4...10. As can be seen from Table 8.8, the precision reaches a maximum of 83 per cent at attribute number=6, and a minimum of 25 per cent at attribute number=8.

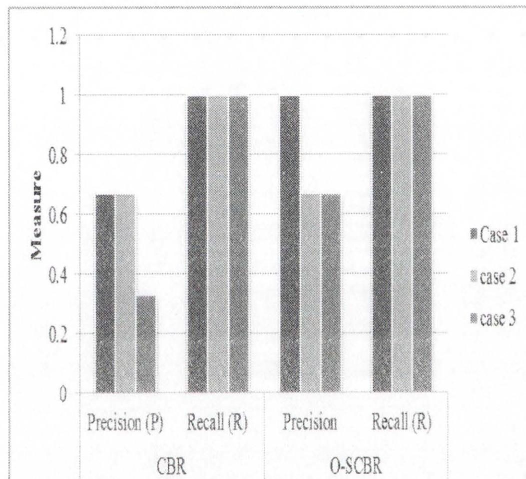
Table 8.8: Initial experiment data

Number of attributes	Cases	CBR				OS-CBR			
		Precision(P)	Recall (R)	F-measure	OA	Precision(P)	Recall (R)	F-measure	OA
2	Case I	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Case II	0.50	1.00	0.67	1.00	1.00	1.00	1.00	1.00
	Case III	0.50	1.00	0.67	1.00	0.50	1.00	0.67	1.00
3	Case I	0.67	1.00	0.80	1.00	1.00	1.00	1.00	1.00
	Case II	0.67	1.00	0.80	1.00	0.67	1.00	0.80	1.00
	Case III	0.33	1.00	0.39	1.00	0.67	1.00	0.80	1.00
4	Case I	0.75	1.00	0.86	1.00	1.00	1.00	1.00	1.00
	Case II	0.50	1.00	0.67	1.00	0.75	1.00	0.86	1.00
	Case III	0.25	1.00	0.29	1.00	0.75	1.00	0.86	1.00
5	Case I	0.60	1.00	0.75	1.00	1.00	1.00	1.00	1.00
	Case II	0.40	1.00	0.57	1.00	0.80	1.00	0.88	1.00
	Case III	0.40	1.00	0.57	1.00	0.60	1.00	0.75	1.00
6	Case I	0.83	1.00	0.91	1.00	1.00	1.00	1.00	1.00
	Case II	0.67	1.00	0.80	1.00	0.83	1.00	0.91	1.00
	Case III	0.33	1.00	0.49	1.00	0.50	1.00	0.67	1.00
7	Case I	0.71	1.00	0.83	1.00	0.88	1.00	0.94	1.00
	Case II	0.71	1.00	0.83	1.00	0.86	1.00	0.92	1.00

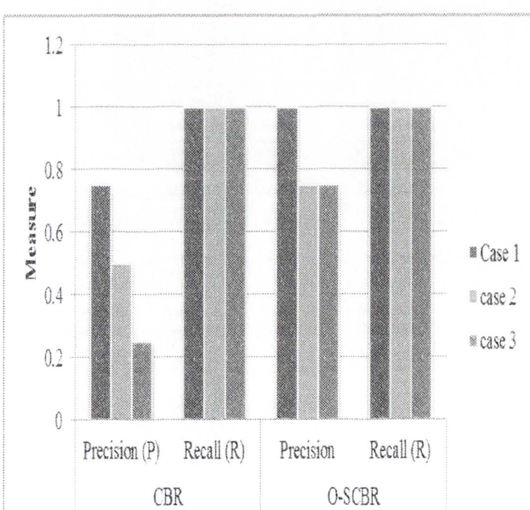
	Case III	0.29	1.00	0.45	1.00	0.57	1.00	0.73	1.00
8	Case I	0.75	1.00	0.86	1.00	0.88	1.00	0.93	1.00
	Case II	0.63	1.00	0.77	1.00	0.88	1.00	0.93	1.00
	Case III	0.25	1.00	0.29	1.00	0.63	1.00	0.77	1.00
9	Case I	0.78	1.00	0.87	1.00	0.89	1.00	0.94	1.00
	Case II	0.67	1.00	0.80	1.00	0.89	1.00	0.94	1.00
	Case III	0.33	1.00	0.49	1.00	0.89	1.00	0.94	1.00
10	Case I	0.80	1.00	0.88	1.00	0.90	1.00	0.95	1.00
	Case II	0.60	1.00	0.75	1.00	0.80	1.00	0.88	1.00
	Case III	0.30	1.00	0.46	1.00	0.60	1.00	0.75	1.00
average		0.56	1.00	0.68	1.00	0.80	1.00	0.88	1.00



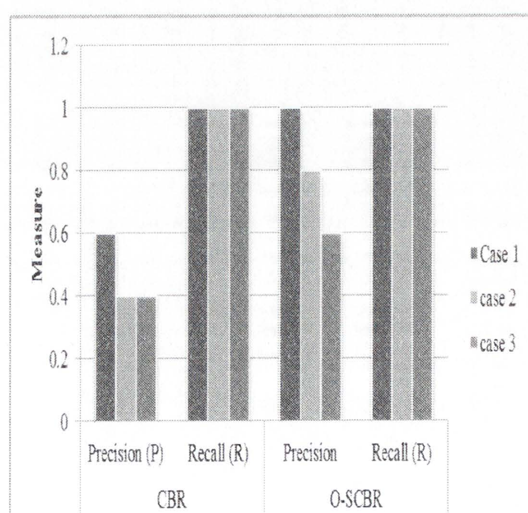
(1) Number of attributes=2



(2) Number of attributes=3



(3) Number of attributes= 4



(4) Number of attributes= 5

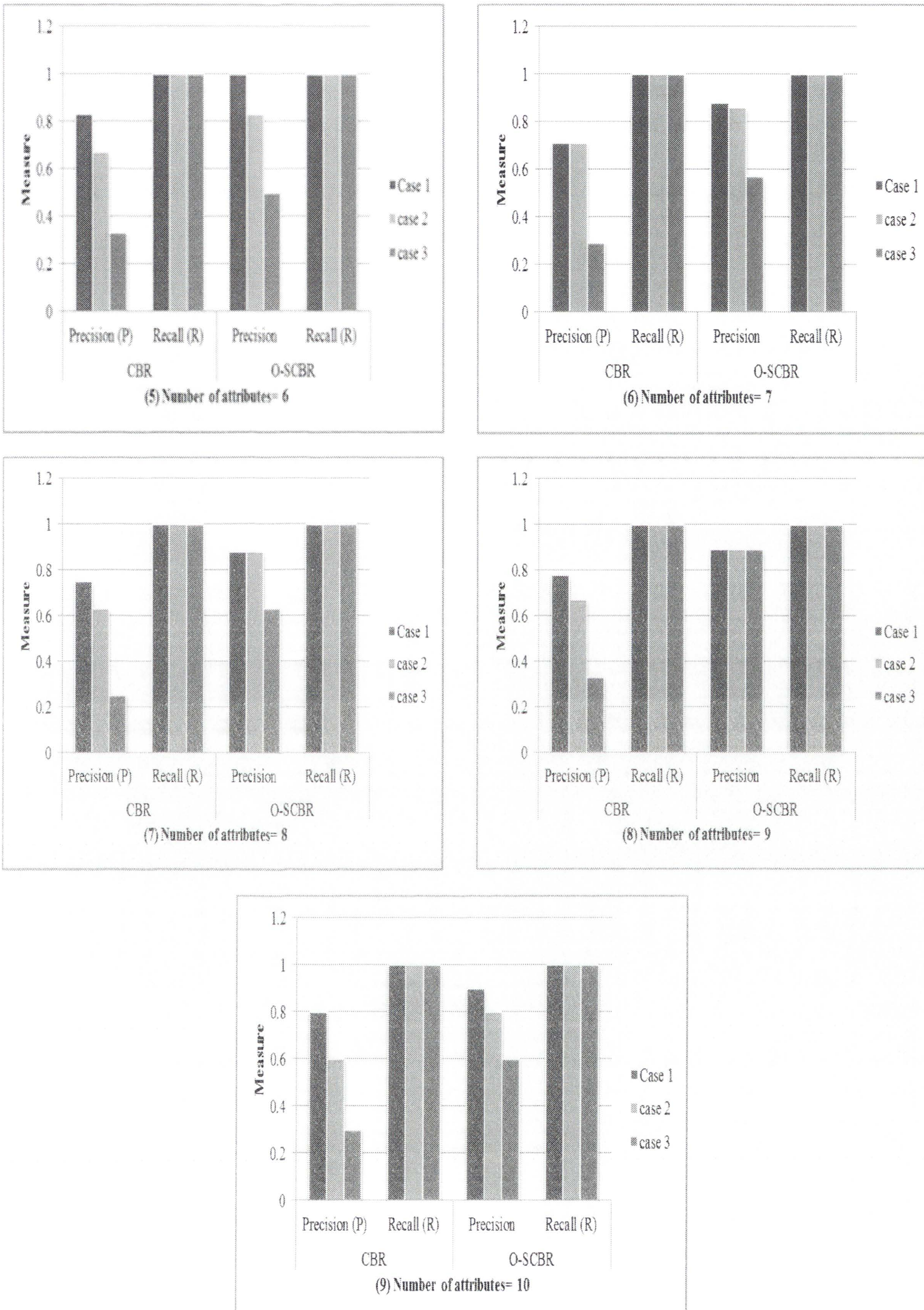


Figure 8.7: Precision and recall of OS-CBR similarity measurement

8.4.2 Experiment II

In the second experiment, the effect of the number of attributes on cases retrieved for the OS-CBR approach were compared, as shown on the right of Figure 8.7. Each of these nine graphs shows precision is affected by the number of attributes, while recall stay firmly at 100% across the all number of attributes. Several tests were conducted to verify the performance of the OS-CBR approach, two of which are presented here.

Using the same assumption as in Experiment I, the attribute number=3 was considered. According to Table 8.8, OS-CBR is able to retrieve two cases at a precision and a recall of 100 per cent, and one other case at a precision of 50 per cent. The result is shown on the right of Figure 8.7 (1).

Second, one more attribute, terrorism group (Al Qaida), with a weight of 100 per cent was added. OS-CBR would retrieve one case at a precision of 100 per cent, and two cases at a precision of 67 per cent. The right side of Figure 8.8 shows the precision and recall scores for k-attributes, where *k*=3, 4...10. As seen in Table 8.8, the precision reaches the maximum of 100 per cent at attribute number=2, 3, 4, 5 and 6. The precision reaches the minimum of 50% at attribute number=2 and 6.

Comparing the performance of the two approaches in the experiments, shown in Figure 8.7, the OS-CBR approach was found to have significantly better performance than the CBR approach.

Another way to examine these results is to compare the F-measure for the three cases in our experiments, shown in Figure 8.8. CBR always suggests Case I will have better performance than Cases II and III. For example, when the attribute number= 6, Case I is preferred because it has the best F-measure of 91 per cent, compared to the F-measures of 80 and 49 per cent for Cases II and III respectively. As shown in Figure 8.9, OS-CBR reaches an F-measure of 1.00, 0.91 and 0.67 for Case I, Case II and Case III respectively (attribute number= 6).

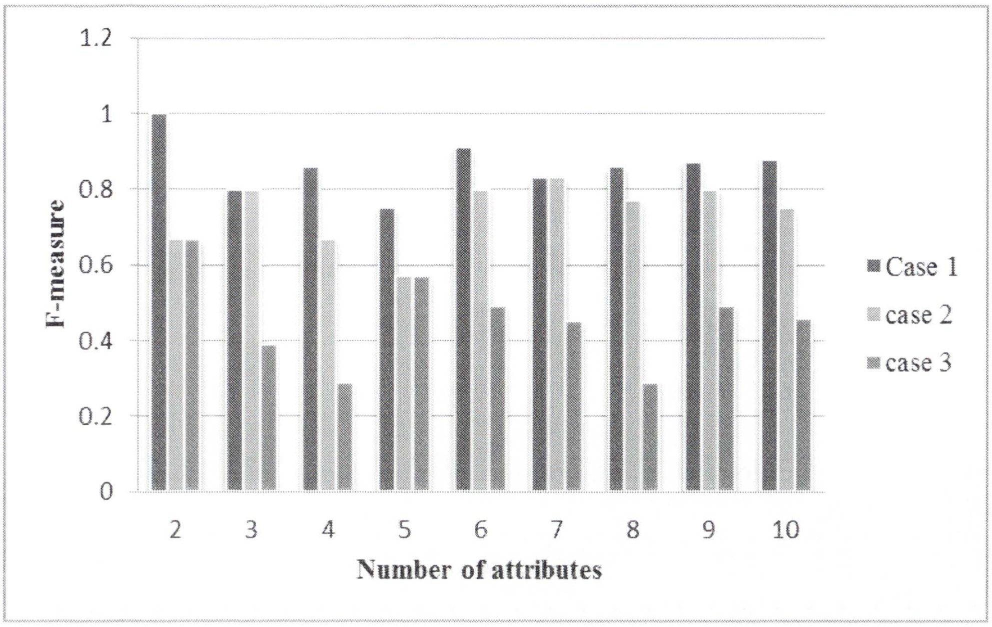


Figure 8.8: F-measure against k-attributes for CBR

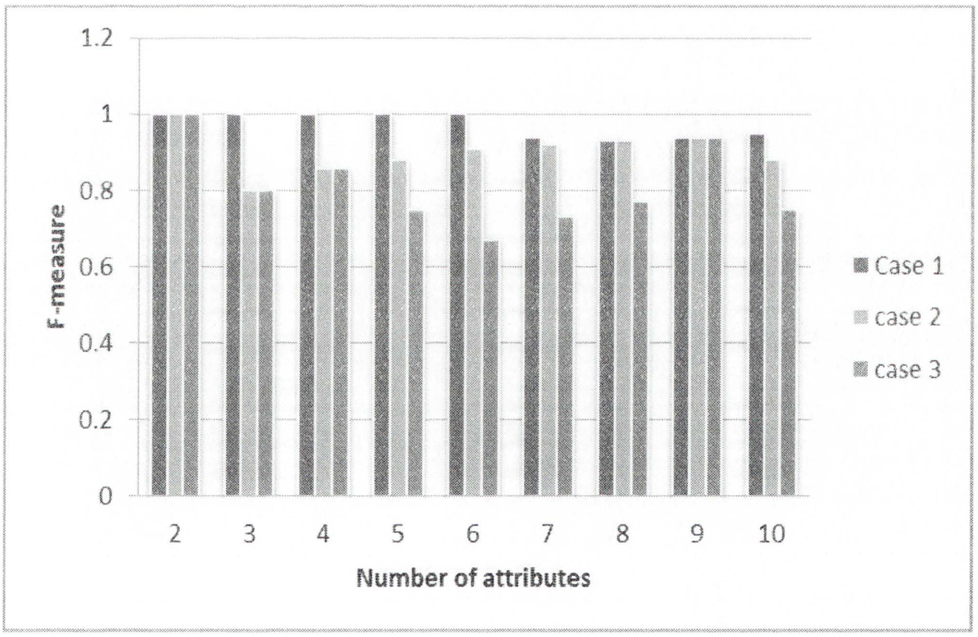


Figure 8.9: F-measure against k-attributes for OS-CBR

To summarize, the results are presented in Figure 8.10 as a graph of precision similarity against *k-attributes*. As expected, in terms of similarity, the OS-CBR approach offers the best performance across all *k-retrieved* cases with a stable overall accuracy compared to the CBR approach.

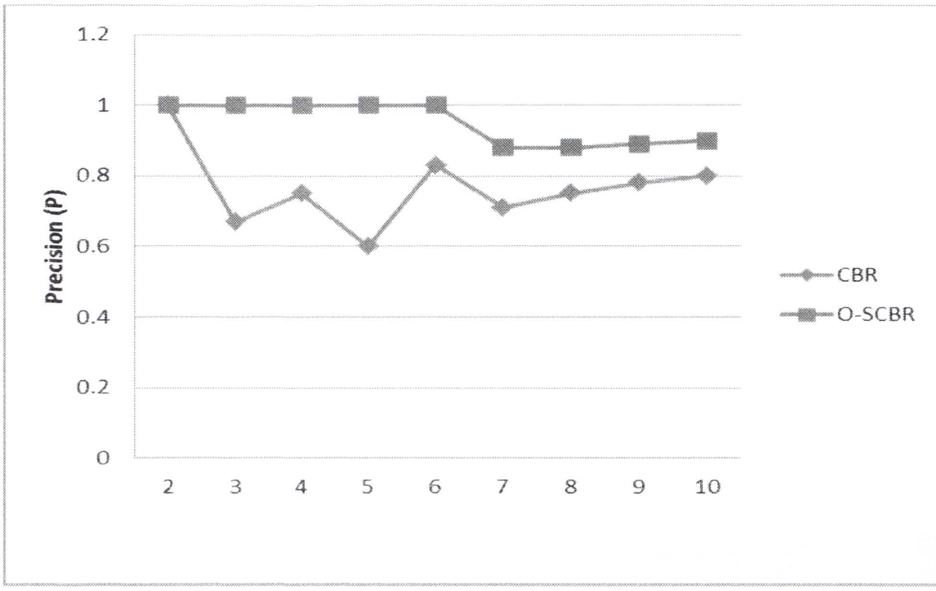


Figure 8.10: Precision similarity against k-attributes

8.4.3 OS-CBR Evaluation

The whole OS-CBR was evaluated based on a survey form as shown in Table 8.9, the mean rating and SD for each survey question (Statement) were calculated. Questions were categored into four grouped: *easy of use*, *usefulness*, *disaster information presentation* and *overall*. Each question evaluates OS-CBR based either on information usefulness perspective or on usability perspective

In question 1 of Table 8.9, subjects agreed, can easily use the OS-CBR with overall average rating of 4.26 (Questions 1, 2 and 3 of Table 8.9). This reflects that OS-CBR is easy to use with average rating of 4.22, functions of the OS-CBR are easy to learn with average rating of 4.44, and it is easy to become skilful in using the OS-CBR with average rating of 4.11.

OS-CBR received an overall rating of 4.32 in usefulness evaluations. Subjects agreed that the OS-CBR helped subjects to understand how to evaluate the disaster situation more quickly, which is the highest usefulness in other aspects (Questions 4-12). OS-CBR also improved the efficiency and effectiveness of usability with average rating

4.22 and 4.44 (Questions 7 and 8 of Table 8.9 respectively). OS-CBR was scored lowest in question related to consistency with average rating 3.89 (Question 11 of Table 8.9).

In the disaster information presentation evaluation, OS-CBR received an overall average rating of 4.30. For example, subjects in the experiment thought that the generated report helped to understand the current decision support situation with average rating of 4.67. OS-CBR could helped subjects to make a final decision, for example question 16 of Table 8.9 scored an average rating of 4.0.

In the overall rating of OS-CBR evaluation is 4.20. Subjects thought their mental workload in OS-CBR were reducing with average rating of 4.44 (Question 20 of Table 8.9). OS-CBR helped subjects to make decision more confidently with average rating of 4.11. OS-CBR also helped subjects to found accurate answers to disaster situations, and ability to solved inputs query with average rating of 3.89 and 4.33 respectively (Questions 22 and 24 of Table 8.9).

In terms of usefulness, the overall average rating of OS-CBR is 4.30, which reflects the information presented by OS-CBR is helpful for emergency response system in disaster situation. In terms of usability, the overall average rating is 4.18, which reflects the information generated by OS-CBR is easy to use for emergency response system.

The ultimate goal of OS-CBR process is to support the decision makers in case of a disaster situation for decision making, such as recalling past experience (Question 12), evaluating and understanding the disaster situation (Questions 8 and 9), and developing solutions (Questions 22,23, and 24). In this sense, the argument of OS-CBR is achieved.

Table 8.9: OS-CBR Performance

STATEMENT	Subjective Rating	Mean Rating	Standard Deviation
EASY OF USE			
1. The system is easy to use.	2	4.22	0.83
2. Functions of the OS-CBR are easy to learn.	2	4.44	0.73
3. It is easy to become skillful in	2	4.11	0.60

using the OS-CBR .			
USEFULNESS			
4. The OS-CBR system is useful for training purposes.	1	4.44	0.73
5. The OS-CBR system is useful as a decision support.	1	4.67	0.5
6. The OS-CBR system helps to evaluate the disaster situation	1	4.11	0.60
7. The OS-CBR helps me to evaluate the disaster situation more efficiently	1	4.22	0.83
8. The OS-CBR help me to evaluate the disaster situation effectively.	1	4.44	0.53
9. The OS-CBR helps me to understand how to evaluate the disaster situation more quickly	1	4.56	0.53
10. OS-CBR system has ability to ''solve'' input query problems	1	4.33	0.5
11. OS-CBR system has ability to perform the promised service consistently?	1	3.89	0.33
12. The OS-CBR system contains all the essential cases that could be used to generate solutions to all possible current cases	1	4.22	0.67
DISASTER INFORMATION PRESENTATION			
13. The generated report help me to understand the current decision support situation	1	4.67	0.5
14. The generated report helps me to come up with faster and well-planned actions.	1	4.33	0.71
15. The generated report helps me to seek further situation knowledge.	1	4.44	0.73
16. The generated report helps me to make a final decision.	1	4	0.5
17. The report can be easily understood.	2	3.89	0.60
18. The generated report is reasonable.	1	4.44	0.53
OVERALL			
19. The user interface of OS-CBR is user friendly.	2	4.22	0.67
20. OS-CBR helps me to reduce mental workload during the decision support process decisions more c	1	4.44	0.53
21. OS-CBR helps me to make decisions support more confidently.	1	4.11	0.60

22. OS-CBR helps me to find accurate answers to the situations.	1	3.89	0.60
23. Overall, the OS-CBR system is reliable.	1	4.22	0.44
24. OS-CBR system has ability to "solve" input query problems.	1	4.33	0.71

8.5 Chapter Review

This chapter represents the experiments of the major algorithm, approach and the prototype system developed in this research. The key results of the experiments are as follows:

- The OBIE approach proved highly accurate. Overall, the system correctly identifies and classifies an average 95 per cent of the instances contained in SMS text. Recall reaches an average of 92 per cent and precision reaches an average of 98 per cent.
- This chapter experimented with the proposed approach (OS-CBR) using three different cases. The results show the F-measure values reached a high level (0.75–1.00 range) with an average of 88 per cent for all cases retrieved. The experiments indicate that adding ontology is beneficial for cases of similarity. This study focused on data generated by authors to test the usability of the proposed approach but more cases are needed to provide a suitable level of complexity.

Chapter 9: Conclusions and Future Study

Problems cannot be solved at the same level of awareness that created them.

Albert Einstein

This chapter concludes this thesis by addressing the main research objectives and linking them to the research questions that were stated in Chapter 1. It highlights the main research contributions and the research limitations and discusses future prospects for research.

9.1 Research Overview

m-Government is the next expected direction of the evolution of e-Government, which provides more access to information and services through wireless communication networks and mobile devices. An MERS, as an important new m-Government service, is designed to offer a new opportunity for interaction among government, citizens, responders and other non-government agencies in emergency situations and thereby improve the services of the government in such situations. The purpose of this research is to present an intelligent MERS framework with its components.

The idea of a mobile-based information system and its components is built based on a consistent theoretical model that was established through reviewing related literature in emergency response system, IE, CBR and ontology. The literature showed that a mobile-based information system would make interactive communication tools that can enable just-in-time communication and collaboration among large numbers of people, and allows the making of rapid decisions in a disaster situation(s).

In attempting to facilitate the use of mobile technologies to assist government to access information and respond to disasters, a conceptual and technical framework was developed to describe an MERS system within m-Government services. Based on this framework, a set of algorithms and approach were developed and implemented in a prototype system.

9.2 Research Contributions

The main contributions of this research are as follows:

- The conceptual and the technical frameworks of an intelligent MERS were proposed. The major characteristics of the MERS framework are the provision of intelligent channels for sharing information, the coordination of the responses of social networks, and the facilitation of decision making in emergencies. The MERS conceptual framework consists of four main components: inputs, processes, outputs and outcomes. The kernel component of the MERS framework is theory and the process of emergency response services, which is mainly composed of registration services, monitoring services, analysis services, decision support services and warning services.
- Methods for representing and processing domain knowledge were proposed. The domain knowledge system to support the MERS were presented as a fundamental part of the MERS. The knowledge-based system developed here consists of two main parts: ontology representation and CB domain. In this thesis, the ontology for the SMS domain has been developed for the purpose of experimental text classification. In Chapter 5, the ontology-based approach was used to present a theory to improve the performance of IE systems, followed by a brief explanation of case representation and indexing. Then, the ontology for the CBR approach is presented in Chapter 6 to provide a formal semantic representation of the objects for case representation.
- An extraction and aggregation algorithm was developed, which makes up the core part of the MERS framework. It is based on ontology and a statistical model to extract information from SMSs. The proposed algorithm can

extract many semantic elements of emergency information such as disaster location, disaster event and status of disaster.

- An OS-CBR approach for decision support was also developed. This approach improves the efficiency of decision makers in an emergency situation. It is based on a combination of the CBR with ontology. Ontology was used to provide a formal semantic representation of the objects for case representation. Three algorithms (case retrieval, case adaptation and knowledge retrieval) were developed.
- A prototype system was designed according to the MERS framework and IS techniques. The development of MERS was used as a test bed for the evaluation of a related approach and algorithms. MERS was also evaluated as a system.

9.3 Research Limitations

The limitations of this research can be summarised as follows:

- Despite every effort made to collect as many SMSs as possible, only a sample of one hundred SMSs was generated. A larger data set is required to further evaluate the OBIE algorithm and to determine its optimal performance.
- Although the experimental results suggest that the proposed OS-CBR approach effectively generates a solution for decision support, the cases were limited. More cases in different disaster situations are required to provide a suitable level of complexity and to further evaluate the approach of this thesis. In addition, more detailed experiments are required by larger data sets from a variety of data sources to evaluate experiments.
- As this study focused on an MERS and its risks, one type of the MERS provision process outcomes was sectioned off. MERS risk management is an essential topic that demands separate, comprehensive research.

9.4 Future Prospects

Work presented in the thesis will be further developed and extended. The CBR approach was used to improve the efficiency of decision makers in an emergency situation. Therefore, more cases are needed to provide a suitable level of complexity.

Future studies should also try to focus on developing mechanisms for easier integration of an MERS solution with existing emergency response systems (traditional and web-based emergency systems) and for supporting easier knowledge management in the system.

Abbreviations

3G	Third-Generation Mobile
AI	Artificial Intelligence
ALI	Automatic Location Identification
ANI	Automatic Number Identification
ANN	Artificial Neural Network
BOW	Bag of Words
CB	Case Base
CBR	Case-Based Reasoning
CRF	Conditional Random Field
DSS	Decision Support System
e-Government	Electronic Government
ENS	Emergency Notification Systems
FOSS	Free and Open Source Software
G2B	Government To Businesses
G2C	Government To Citizens
G2G	Government To Government
GA	Genetic Algorithm
GPS	Global Positioning System
HMM	Hidden Markov Model
ICT	Information Communication Technology
IE	Information Extraction
IR	Information Retrieval
IS	Information System
RDMS	Relational Database Management System
ITU	International Telecommunications Union
JDBC	Java Database Connectivity
KB	Knowledge Base
KN	Knowledge Need
KR	Knowledge Retrieval

ME	Maximum Entropy
MERS	Mobile-based Emergency Response System
m-Government	Mobile Government
m-Services	Mobile Services
MySQL	Structured Query Language
NER	Named Entity Recognition
OA	Overall Accuracy
OBIE	Ontology-Based Information Extraction System
OP	Organisation Profile
OS-CBR	Ontology-Supported Case-Based Reasoning
OWL	Web Ontology Language
P	Precision
PDAs	Personal Digital Assistants
POS	Part Of Speech
PSAP	Public Safety Answering Point
KR	Knowledge Requirements
R	Recall
RDF	Resource Description Framework
RM	Risk Management
SA	Situation Awareness
SDLC	Systems Development Life Cycle
SMS	Short Message Service
SVM	Support Vector Machine

Glossary

Aggregation aims to combine a finite number of observed values into a single output.

Analysis application functions to support crisis classification, identifying related experts to contact, searching for background information and facilitating knowledge sharing.

Bag of Words is a common model for representing a text in a learning-based system. The BOW model is based on a vector representation of a text.

Case in this system represents an emergency response experience and consists of three main parts (problem, solution, and outcome).

Case adaptation is the process of transforming the most similar cases retrieved from the case base into a solution appropriate for the current problem.

Case-based reasoning is an intelligent method to solve new problems by reusing appropriate information and knowledge of a previous experience.

Case indexing refers to the features that stored cases should have for retrieval and comparison tasks.

Case representation in this study involves several levels of detail: specification of the problem, solutions and outcome.

Case retrieval of previous cases that are similar to the new problem is undertaken by the CBR system from a case base (CB).

Case revise and retain mean that the suggested solutions are revised for suitability by experts and the revised solutions are then retained temporarily in the disaster database.

Conditional random field is a probabilistic framework for labelling and segmenting structured data, such as sequences, trees and webs.

Conjunction of features refers to incidence features**.** For example, the conjunction of two or more tokens is used as features, which is the token phrase.

Connectors provide a method for querying and updating data in a database.

Class properties are binary relations of classes (i.e. properties link two classes together) in ontology.

Data acquisition is used to automatically extract structured information from unstructured information.

Decision support system is a computer-based information system that supports decision-making.

Decision support application is used to facilitate information gathered and provides consultation information.

Disaster management in this study mainly deals with man-mad disasters such as large-scale terrorism, chemical spills, nuclear radiation evacuations, utility failures, epidemics, crashes, explosions and urban fires.

Disaster organisations involved in an emergency response system include residents, government agencies, businesses, volunteer organisations and experts.

Domain interest model is the model according to which the ontology must be designed (i.e. the domain interest of SMS text).

e-Government is defined as the use of ICT, in particular the Internet, to provide access to government information and services.

Emergency notification systems are used to notify people through phone, e-mail or websites. Some systems also permit the delivery of messages to pagers, and SMS.

Emergency response ontology in this study has been developed for the experimental purposes of case classification.

Extraction methods used for IE are classified into two categories: hand-coded or learning-based and statistical or rule-based.

Free and open source software is available to anyone to use, modify and distribute as they wish at no cost.

F-measure is a combined measure of precision and recall.

Genetic algorithm is a search experimental that mimics the process of natural evolution.

Hand-coded method requires human experts to define rules or regular expressions for carrying out the extraction.

Hidden Markov model is a probabilistic process over a finite set (states). Each state-transition generates a character from the alphabet of the process.

Information extraction is a technology for finding facts in plain text, and coding them in a logical representation such as a relational database.

Information processing: Information processing is the task of finding specific pieces of information from unstructured or semi-structured documents.

Information retrieval is based on keyword indexing systems and Boolean logic queries that are sometimes supplied with statistical methods.

JAVA method library includes the operational level (i.e. the implementation) of IE methods and OS-CBR methods at the knowledge level.

Knowledge base stores information about a specific problem solving experience. It contains cases and rules.

Knowledge needs are used to help find the right knowledge in the case of sharing and to enable the creation of the right knowledge in the case of creation.

Knowledge requirements may include modules, processes and method, which may have different specification to describe them. The specification of needs allow accurate knowledge search or creation.

Learning-based method requires a manually extracted, labelled, unstructured template that contains pre-specified types of events for training.

Lexical information about disaster events is required by ontology to enable the detection of named entities in an SMS.

Lexical analysis is the first step in handling the SMS text by dividing the stream of characters into words or, more precisely, tokens.

Maximum Entropy Model is a flexible statistical model that assigns an outcome for each token based on its history and features.

MERS prototype is comprised of six subsystems: Storage system, Ontology Management, Connectors, Java Method Library, OBIE tasks and OS-CBR tasks

MERS risks identifies the basic requirements or factors that need to be taken into account when building MERS services: Organisational Characteristics, Human Capacity, Financial Capacity, and Technical Infrastructure.

OBIE tasks are a sequence of tasks that must be solved by the decomposition method.

Merging structure is a step referred to as relation extraction for cases in which two entities are associated.

Mobile-based emergency response system has been designed as an important new service of m-Government. It aims to support people (mobile users) by enabling them to provide information to the government about an emergency situation through their mobile phones and also enables them to access helpful advice to reduce risks.

m-Government is the next expected direction of the evolution of e-Government, which provides more access to information and services through wireless communication networks and mobile devices.

m-Government services apply to four main dimensions of the public sector: m-Communication, m-Services, m-Democracy and m-Administration.

Monitoring application constantly monitors a crisis and quickly reports in charge of analysis module.

Named entity recognition aims to identify and classify every token in a text into some predefined categories like location name, organisation name, person name, date and time.

Normalisation and duplication puts information into a standard format by which it can be reliably compared.

Ontology stands for a structured framework for the representation of information and knowledge in the computer science field.

Ontology-based information extraction system is an algorithm within a mobile-based emergency response system (MERS) to automatically extract information from a Short Message Service (SMS).

Ontology development process describes the steps of domain ontology development process. At each stage, there are activities to be implemented.

Ontology management was facilitated by the use of OntoBridge Java library for OBIE and OS-CBR ontology.

Ontology-Supported Case-Based Reasoning (OS-CBR) is an approach to allow a more convenient case retrieval process in an emergency situation in order to draw conclusions and to give recommendations based on knowledge from past disasters.

Organisation profile stands for a personalisation of a service that allows a user to query particular needs. It is a group of settings that define how KP-MERS is set up for a specific user.

OS-CBR tasks are defined as a sequence of tasks that are solved by decomposition method.

Overall accuracy can be computed as the total number of correct class predictions and total number of incorrect predictions divided by the total number of tokens in SMS text messages.

Part of speech (POS) information refers to the POS values of the current token, the previous two and the next two words, which have been used as features in this system.

Pattern feature is used to determine a set of decision rules that would produce a positive example.

Precision scores measures the ratio of relevant information that was retrieved against all the information that was retrieved.

Pre-processing (lookup resources) to collect the data is obviously the first task in IE systems.

Previous token tags are helpful features for capturing information on the interdependency of the label sequence.

Recall score measures the ratio of the relevant information retrieved from the cases against all the available relevant information present in the cases.

Registration application keeps track of all entities of interest in the disaster area such as relief organisation, experts and mobile users.

Representation of input data of an OBIE is in the form of SMSs.

Risk management is a system whose purpose is to provide a generic method to define, implement, and improve the MERS project processes. Moreover, it provides public organisations with appropriate support in the planning and management phases and guarantees integration between different m-Government projects.

Rule-based method requires a collection of rules and a set of policies that control the rules.

Similarity measures in the MERS system are calculated by measuring similarities based on four different types of features: disaster location, physical target, disaster event and disaster weapon used.

Situation assessment is responsible for assessing current situations and then aiding decision makers to develop their situation awareness (SA) of the disaster environment.

Slipping window: typically, word windows are of size 5 consisting of the current token, two tokens to the left and two tokens to the right.

SMS text classes are required by the ontology because it needs individuals that represent objects in the domain of discourse in order to be able to connect individuals with their real world equivalents.

Statistical method uses a statistical model to make decisions if candidate information is present in a given text.

Storage system is to store all information about a disaster situation, which will be the data source of IE processes and CBR processes.

Tokenisation models refer to the process of creating tokens from an SMS.

Traditional emergency response systems are based on two communications models: 1) many-to-one, a telephone-based emergency report system and 2) one-to-many, a top-down aid to the distribution system.

Warning application is used to identify parties for notification and facilitate the generation and distribution of warning information.

Web-based emergency systems mean that emergency responders now have the ability to access this enormous data via web pages.

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